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LABORATORY BIOLOGY

INVESTIGATING LIVING SYSTEMS



KASKEL HUMMER KENNEDY ORAM

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CANADIAN SI EDITION 

LABORATORY BIOLOGY

INVESTIGATING LIVING SYSTEMS

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Preface

LABORATORY BIOLOGY: Investigating Living Systems is a current, up-to-date student manual suitable for the laboratory phase of most introductory biology courses taught at the secondary level. This manual requires students to observe carefully, collect and record data accurately, and interpret their findings for all investigations. Basic processes and concepts of biology are presented in this laboratory program. Its major features include

1. simple, inexpensive equipment that is easily obtained.
2. short, simple step-by-step instructions that allow the student to proceed through the investigation at his or her own pace.
3. illustrations showing certain procedural steps to help reinforce the written instructions.
4. performance objectives for the student that provide a guide for quickly determining what is expected of the student during the investigations.
5. use of models and simulations to simplify abstract concepts or those not easily understood.
6. use of preserved instead of living materials wherever possible.
7. the development of several aspects of scientific literacy: scientific vocabulary, use of laboratory equipment and modern laboratory techniques, use of the scientific method, and working with tables and graphs.

LABORATORY BIOLOGY: Investigating Living Systems is a completely self-contained laboratory manual. All observations, data, and answers are to be recorded in the spaces and lines supplied in the manual. No extra paper or notebook is needed. Data charts, graph axes, and space for diagrams are included. All of these features are designed to facilitate individualized learning.

The use of live specimens has been kept to a minimum in *LABORATORY BIOLOGY: Investigating Living Systems*. Many of these living specimens, such as yeast, *Elodea*, seeds, and green onions, are easily obtained in grocery or pet stores. Certain living specimens such as bacteria and bread mold may be easily cultured or grown in the laboratory.

Many investigations promote independent study and self-reliance in mastering difficult concepts via simple, practical approaches. One of these approaches is the use of paper models of biochemical molecules. Models are conveniently located together in the Teacher's Annotated Edition of *LABORATORY BIOLOGY: Investigating Living Systems* to enable you to reproduce only the amounts you need for your class. A second approach used in some investigations involves only the manipulation of ideas. These "paper and pencil" exercises require only the material provided in the lab manual. These investigations can be done outside of class if desired.

Almost every investigation in *LABORATORY BIOLOGY: Investigating Living Systems* can be completed within a single laboratory period. However, some investigations require two days to complete and a few involve daily or weekly observations. None of the labs requires field trips, but some, such as those on ecology, may be adapted for field trips if desired.

The 82 laboratory investigations in this manual are representative of the topics covered in most introductory biology courses. *LABORATORY BIOLOGY: Investigating Living Systems* also follows the same sequence and reinforces concepts presented in *BIOLOGY: Living Systems*.*

Grateful acknowledgement is extended to the members of the Merrill Science Department for their part in making this laboratory manual possible.

**BIOLOGY: Living Systems*, Oram, Hummer, and Smoot. Charles E. Merrill Publishing Co., Columbus, OH, 1983, 1979, 1976, 1973

To the Student

Working in the laboratory throughout the course of the year can be an enjoyable part of your biology experience. *LABORATORY BIOLOGY: Investigating Living Systems* is a tool for making your laboratory work both worthwhile and enjoyable.

The laboratory exercises are designed to fulfill the following purposes:

- to help stimulate your interest in science as a whole, and especially in biology;
- to reinforce important concepts and ideas studied in your text;
- to allow you to verify some of the scientific information learned through lectures or text readings;
- to allow you to discover for yourself biological information, concepts, and ideas not necessarily covered in lecture or in text readings; and
- to acquaint you with many modern tools and techniques being used by today's biological scientists.

Most importantly, the laboratory investigations will give you first-hand experience in how a scientist works. You will be presented with a problem. Then, through use of the scientific method, you will seek answers through experimentation. Your conclusions (answers to problems) will be based on your observations alone or on observations made by the entire class, recorded experimental data, and your interpretation of what the data and observations mean.

Each investigation in *LABORATORY BIOLOGY: Investigating Living Systems* has the five parts listed below. Understanding the purpose of each of these parts will help make your laboratory experience easier.

1. **Introduction**—The introduction is in a box directly under the title of each investigation. These paragraphs tell you why the investigation is being done and give you needed background information.
2. **Objectives**—The objectives are in the box directly below the introduction. This section always begins, "In this investigation, you will . . ." These statements are a guide to what will be done in the investigations and what will be expected of you.
3. **Materials**—The materials section lists the supplies you will need to complete the investigation.
4. **Procedure**—The procedure gives you step-by-step instructions for carrying out the investigation. Unless told to do otherwise, you are expected to complete all parts of each assigned investigation. Steps which actually direct you to perform part of the investigation are marked with the symbol ●. You may want to put a check mark in front of each step as you complete it to make sure you have followed the procedure as written and to help you keep your place. Important information needed for the investigation but that is not an actual procedural step is also found in this section. These paragraphs have no special symbol. Diagrams and tables are included in this section to help you complete the investigation. Figures and tables in which you are to record data are referenced in the procedural statements. Many investigations have safety precautions listed in the procedure. Be sure to read these statements and obey them.
5. **Analysis**—In this section you draw conclusions about the investigation just completed. You may be asked to answer questions, complete a graph, or write a paragraph. Rereading the introduction before answering the questions is most helpful.

In addition to the investigations, this laboratory manual has two other features—a glossary and information on safety which includes first aid. The glossary, included in the back of the manual, defines terms used throughout the manual. A pronunciation key has also been included to help you with the more difficult words. Inside the back cover of the manual is information on safety and first aid. Safety in the laboratory is *your* responsibility. Read these sections over now. Being familiar with the correct way to behave in the laboratory will help you to ensure your safety as well as the safety of your classmates.

Working in the laboratory can be a safe and fun learning experience. Using this book will help you make biology more understandable and exciting. Have a good year!

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BIOLOGICAL COMMUNITIES

1

You are probably used to thinking of your city, town, or neighborhood as a community. But did you know that all animals and plants live in communities too? As an introductory investigation to living systems or biology, you will study an important principle—all organisms occur in specific groups called communities. Later in this biology course, you will determine how organisms in a community depend on each other for existence.

In this investigation, you will

- (a) list familiar organisms found in several different communities.
- (b) learn how to identify which organisms in your list are producers and consumers.
- (c) observe and identify a number of different organisms in a soil clump community.
- (d) collect and preserve certain organisms from the soil community for microscopic study in Investigation 2.

Materials

plastic spoon
soil sample
small jar with cover
ethyl alcohol
newspaper
hand lens

Procedure

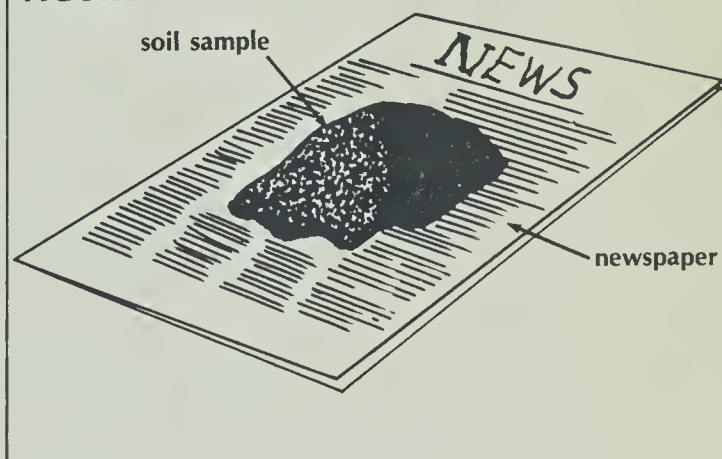
Part A. Biological Communities

- List in Table 1-1 at least four organisms usually found in each type of community shown. For example, a pond community might have turtles, rushes, frogs, and algae (seaweed). Producers (often thought of as plants) usually are green and make their own food. Consumers (often thought of as animals) usually are not green and cannot make their own food.
- Identify the organisms you listed in Table 1-1 as producers or consumers by circling all consumers and underlining all producers.

Part B. A Soil Community

- Place several sheets of newspaper on your desk or laboratory area.
- Place a soil sample on the newspaper. Use Figure 1-1 as a guide. Your soil sample represents a community. Use a spoon to help break up the soil into smaller clumps. Look carefully for any small organisms with a hand lens.

FIGURE 1-1



- Use Table 1-2 to record the name and number of each type of consumer and producer seen in your soil community. Figure 1-2 shows several consumers commonly found in soil. Use these diagrams to help identify the consumers in your community.
- Place small consumer organisms into jars of ethyl alcohol for future microscopic examination.
- Label the container with your name.

TABLE 1-1. BIOLOGICAL COMMUNITIES	
COMMUNITY EXAMPLE	NAME OF ORGANISMS
Home (apartment or house)	
Farm	
Forest	
Ocean	
Desert	

TABLE 1-2. SOIL COMMUNITY			
Name of producer organism	Number of these producers seen	Name of consumer organism	Number of these consumers seen

Analysis

1. Define community (see introduction)._____

2. (a) Define producer. (HINT: Read Part A again if you need help.)_____

- (b) By what common name do we call producers? _____

- (c) What is the color of most of the producers in your soil community? _____

- (d) List four producers that you eat. _____

3. (a) Define consumer. (HINT: Read Part A again if you need help.) _____

- (b) By what common name do we call consumers? _____
- (c) What is the color of most of the consumers in your soil community? _____
- (d) On what do many consumers such as cows and horses feed? _____
4. List two ways in which all producers and consumers in your community are similar. (HINT: Where do they all live? What do they all do?) _____

5. (a) Do all biological communities have exactly the same kinds of organisms? (Use Table 1-1 as a guide.) _____
- (b) Might all biological communities contain both producers and consumers? _____
- (c) Why are producers important to a community? _____
6. (a) Were there the same number of producers and consumers in your soil community? _____
- (b) Which type of organism, producer or consumer, was present in the greater number? _____
- (c) Why would you expect more producers than consumers in a community (what must producers make for consumers)? _____
7. Biological communities change as moisture, light, and temperature change. Producers must have light to make food.
- (a) Would you expect to find more producers or consumers inside a cave? _____ Explain.

- (b) Would you expect to find more producers near the ocean's surface or along the ocean's bottom? _____ Explain. _____
- (c) Would you expect to find more producers within a square metre of desert or forest? _____ Explain. _____

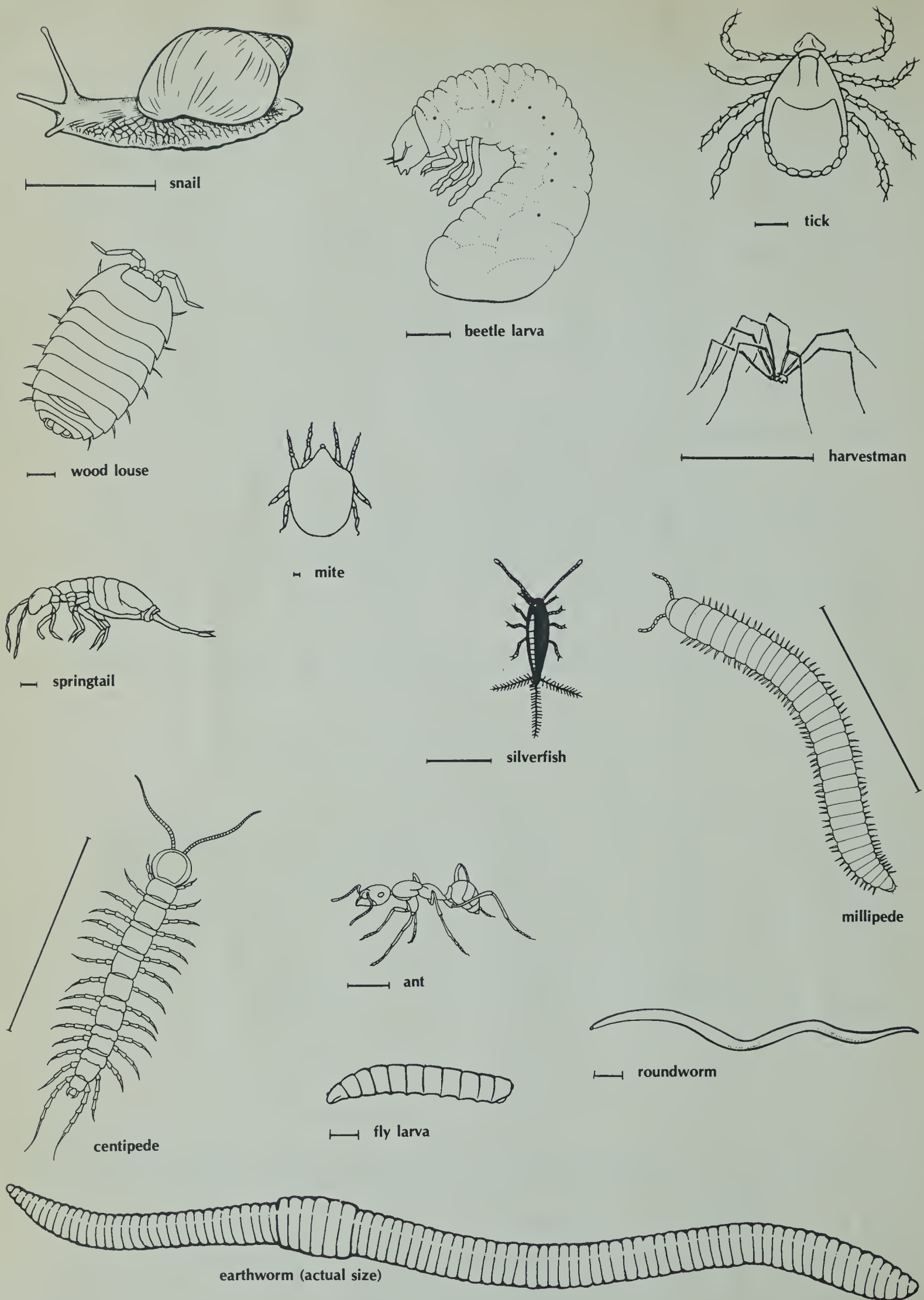


FIGURE 1-2 Line beside each animal indicates approximate actual size.

USE OF THE LIGHT MICROSCOPE

2

Possibly the most important instrument that aids biologists is the microscope. A microscope allows scientists to investigate worlds that are otherwise too small to be seen. An opportunity to learn about and use this valuable instrument is now yours. A light microscope magnifies objects up to approximately 400 times their natural size.

Two types of slides are used with the microscope: prepared slides and temporary wet mounts. Prepared slides are permanent and are made to last a long time. These slides are usually purchased by the school. Most of the slides you will use in this course will be wet mounts. You will make these slides yourself. As the name temporary wet mount suggests, these slides are not permanent.

In this investigation, you will

- practice proper handling of the light microscope (Figure 2-1).
- learn the names and functions of the light microscope parts.
- acquire skill in using the light microscope by carefully following all directions.
- prepare a wet mount of an insect leg.
- locate objects under low and high power magnification.

Materials

light microscope
lamp (if needed or available)
microscope slide

coverslip
tweezers

preserved insect leg
lens paper

water
dropper

Procedure

Part A. Learning Microscope Parts and Functions

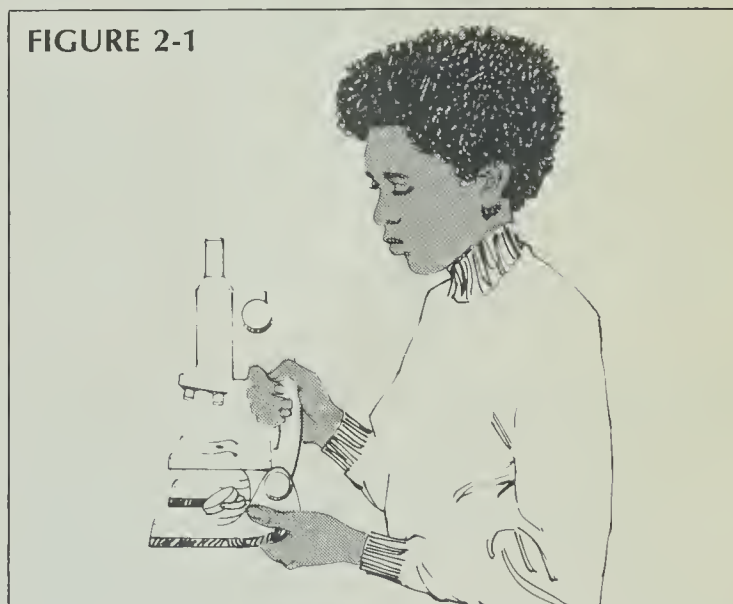
- Look at Figure 2-1. Note that the student is carrying the microscope with two hands. Also note that the microscope is carried straight up. Do not tilt or tip the microscope as you carry it with both hands close to the body.

- A mirror is attached to most microscopes by means of a swivel joint. Position the concave surface (curved surface) of the mirror so that it is turned toward a light source, such as ceiling lights, windows in the room, or a desk lamp. A lamp may be built into your microscope. This lamp replaces the mirror and outside light source. **CAUTION:** *Never use direct sunlight as a light source. Direct sunlight will damage your eyes.*

- Look at Figure 2-2. Use the diagram that looks most like your microscope to locate microscope parts.

1. Does your microscope have a lamp or a mirror?

FIGURE 2-1



2. What type of diaphragm does your microscope have? _____

A diaphragm controls amount of light entering the microscope. Turning the diaphragm adjusts the amount of light passing through the microscope.

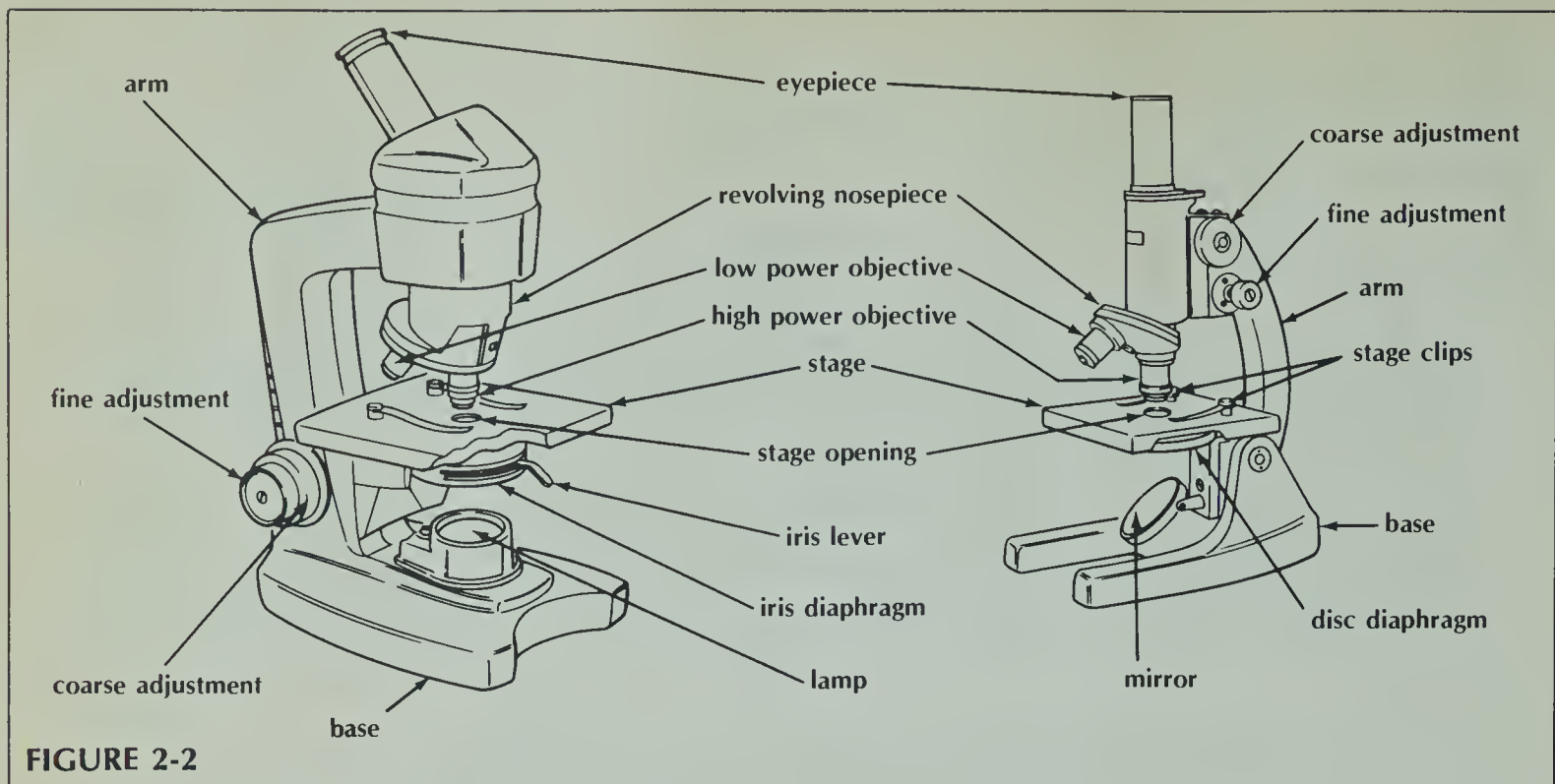


FIGURE 2-2

- Use Figure 2-2 to help you locate the revolving nosepiece, high power objective, and low power objective on your microscope.

The low power objective is identified by a "10X" marking or by its short length. The high power objective usually has a "43X" marking and often is longer than the low power objective. The objectives can be changed by turning the nosepiece (Figure 2-3).

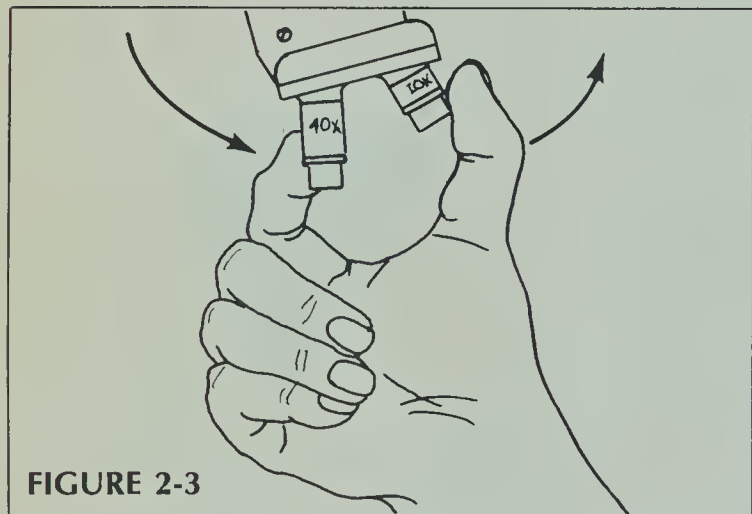


FIGURE 2-3

- Stop and place a check mark in the square next to each part of the microscope you can locate:
- | | |
|--|---|
| <input type="checkbox"/> diaphragm | <input type="checkbox"/> high power objective |
| <input type="checkbox"/> lamp or mirror | <input type="checkbox"/> low power objective |
| <input type="checkbox"/> revolving nosepiece | |

Do not continue with the lab until you know where these five parts are located.

- Use Figure 2-2 to help you locate the eyepiece, coarse wheel adjustment, fine wheel adjustment, stage, and stage opening on your microscope.

- Stop and place a check mark in the square next to each part of the microscope you can locate:

- | | |
|--|--|
| <input type="checkbox"/> eyepiece | <input type="checkbox"/> stage |
| <input type="checkbox"/> coarse wheel adjustment | <input type="checkbox"/> stage opening |
| <input type="checkbox"/> fine wheel adjustment | |

Do not continue with the lab until you know where these five parts are located.

Part B. Using the Microscope

- Turn on the lamp or position the mirror toward the light source.

- Turn and click the low power objective so that it is directly over the stage opening. An objective is in proper viewing position when directly over the stage opening. Most microscopes will "click" when the objective is in proper viewing position.

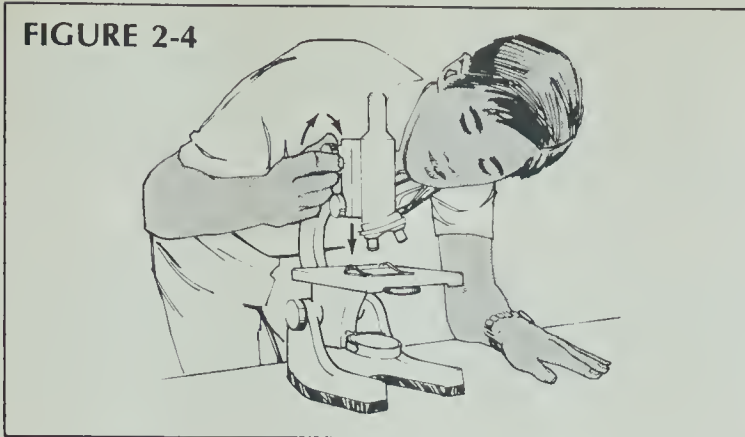
- Look through the eyepiece of the microscope. A circle of bright light should now be visible. Keep both eyes open. Keeping both eyes open will reduce eyestrain.

- Adjust the mirror and diaphragm to make the circle of light as bright as possible.

- Look to the side of the microscope as shown in Figure 2-4. Slowly turn the coarse wheel adjustment back and forth. DO NOT force the wheel once it stops. When the wheel stops, turn it in the opposite direction. Note the movement of the low power objective in relation to the stage.

3. In which direction does the objective move as you turn the coarse wheel adjustment toward you? _____

FIGURE 2-4



4. In which direction does the objective move as you turn the coarse wheel adjustment away from you? _____

The eyepiece contains a glass lens which magnifies 10 times (10X). The low power objective also contains a lens which magnifies 10 times (10X). Therefore, the total magnification of an object when viewed under low power is 100X. Total magnification under low power is calculated by multiplying the magnification of the low power objective (10) by that of the eyepiece (10). The total magnification of an object when viewed under high power is calculated by multiplying the magnification of the high power objective (usually 43) by that of the eyepiece (10).

5. What is the total magnification of your microscope under low power? (Use the numbers printed on your low power objective and eyepiece if present.) _____

6. What is the total magnification of your microscope under high power? (Use the numbers printed on your high power objective and eyepiece.) _____

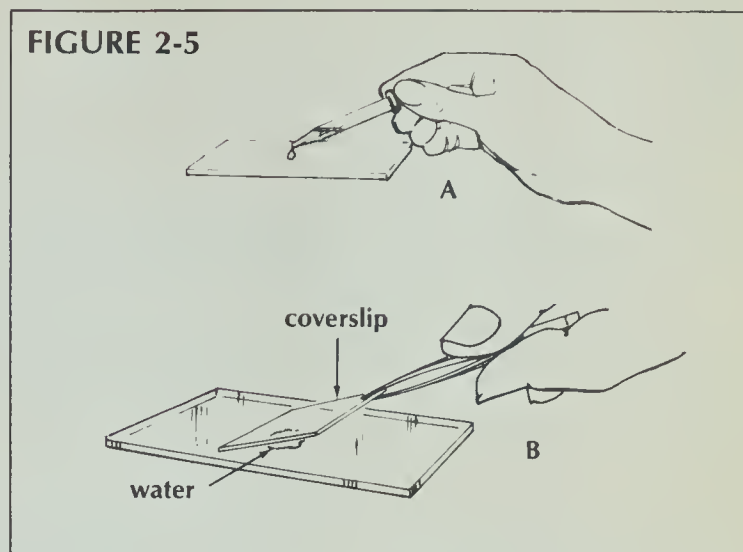
The objectives and eyepiece should be cleaned with lens paper at the beginning of each laboratory period. *Always use lens paper to clean lenses. Other types of paper may scratch or smear lenses.*

- Clean the objectives and eyepiece of your microscope using lens paper. Use one piece of paper and gently wipe each lens.

Part C. Preparation of a Temporary Wet Mount

A temporary wet mount consists of some object placed in a drop of water on a slide with a coverslip over the object. Use the following steps in preparing your wet mount.

FIGURE 2-5



- *Step 1.* Add a small drop of water to a slide as shown in Figure 2-5A.
- *Step 2.* Place the object to be viewed in the water drop. (If available from Investigation 1, use one leg only from one of the insects collected.)
- *Step 3.* Use tweezers to position a coverslip as shown in Figure 2-5B. Use of tweezers avoids getting fingerprints on the coverslip.
- *Step 4.* Lower the edge of the coverslip down slowly over the water drop and object. This procedure will prevent trapping air under the coverslip.

Part D. Locating an Object Under the Microscope

- Click the low power objective into viewing position. NOTE: *Always locate an object first with low power magnification even if a higher magnification is desired.*
- Adjust the diaphragm and mirror for the best light.
- Place the wet mount of the insect leg on the stage of your microscope. Position the slide on the stage so the insect leg is *directly* over the center of the stage opening. Secure the slide in place with the clips.
- Look to the side of your microscope as shown in Figure 2-4. Slowly lower the low power objective by turning the coarse wheel adjustment until the objective almost touches the glass slide. Some microscopes have an automatic stop which prevents lowering the objective onto the slide. Other microscopes do not. **CAUTION:** *Never lower the objective toward the stage while looking through the eyepiece.*

- While looking through the eyepiece with both eyes open, slowly turn the *coarse wheel adjustment* so the objective rises or moves away from the stage. The insect leg should become visible.

- Bring the insect leg into sharp focus by turning the fine wheel adjustment.

Part E. Increasing the Magnification of the Microscope

- Any object to be viewed under high power magnification *is always located first under low power and focused*. Locate and center the insect leg under low power of your microscope.

- Move the low power objective out of viewing position. Look to the side of the microscope and revolve the nosepiece (Figure 2-3). Click the high power objective into viewing position.

- Look through the eyepiece. The insect leg should be visible. However, it may need to be focused. Use the *fine adjustment wheel only* to sharpen the focus. **CAUTION:** *Never use the coarse wheel adjustment for focusing with high power. Damage to the lens and slide may result if the coarse adjustment is used.*

- If you are unable to find the insect leg, then do the following. While looking through the eyepiece, move the glass slide slightly to the left, right, away from, or toward you. These movements may help to reposition the insect leg directly in the center of the high power objective.

- Repeat Parts D and E if you are unable to locate the object under high power.

Analysis

1. Match the microscope parts listed in Column I with their correct function in Column II. Place your answers along the left side of Column I.

Column I	Column II
_____ diaphragm	(a) allows light to pass through stage
_____ stage opening	(b) brings objects into rapid but coarse focus
_____ mirror or lamp	(c) regulates amount of light entering scope
_____ eyepiece	(d) is attached to revolving nosepiece and contains a lens capable of 10X magnification
_____ low power objective	(e) holds glass slide and specimen in place
_____ high power objective	(f) supports slide
_____ revolving nosepiece	(g) directs light into scope
_____ coarse wheel adjustment	(h) turns to change from one power to another
_____ fine wheel adjustment	(i) contains a lens capable of 10X magnification
_____ stage	(j) brings objects slowly into fine focus
_____ stage clips	(k) contains a lens capable of 43X magnification

2. Answer the following statements as true or false.

(a) Total magnification of a microscope is determined by adding the eyepiece lens magnification to the objective lens magnification._____

(b) An object should always be located first with low power._____

(c) A light microscope should be carried in an upright position with both hands._____

(d) The fine wheel adjustment must be used to sharpen focus when using high power magnification._____

(e) Always look to the side of a light microscope when lowering the objective._____

(f) Paper towels or newspaper may be used to clean the lens of a microscope._____

(g) The eyepiece of a microscope is marked 10X. The high power objective is marked 50X. The total magnification is 500X._____

TECHNIQUES FOR BETTER MICROSCOPE USE

3

Several important techniques and ideas must still be mastered in using a light microscope. Just knowing that a microscope magnifies things and learning how to prepare a wet mount are not enough. Knowing how and why your microscope works will enable you to use it better. The techniques and hints presented in this investigation will help you use your microscope correctly.

In this investigation, you will

- learn what the position of an object is when viewed through a light microscope in relation to its position on the microscope stage.
- adjust the diaphragm correctly to achieve proper light under low and high power.
- learn to locate objects at various places in the "depth of field."
- use stains to aid in viewing objects.
- compare the area of view under low and high power magnification.

Materials

light microscope
microscope slide
coverslip
scissors
dropper

absorbent cotton
thread, black
thread, white
magazine page

pond water
hair
potato
tweezers

razor blade (single-edge)
iodine stain
tissue paper
lens paper

Procedure

Part A. Position of Objects When Viewed With a Microscope

● Prepare a wet mount (see Investigation 2) of a lowercase letter "e" from a magazine page.

● Place the wet mount of the letter "e" onto your microscope stage. Position the slide on the stage so the "e" faces you as it would on a magazine page.

● Observe the letter "e" using *low power* on your microscope. (Review the procedure in Investigation 2 if necessary.) Focus the "e" with the fine adjustment.

- What is the position of the "e" viewed with the microscope compared to its position on the stage? _____

● While looking through the eyepiece, move the slide slowly from *left to right*.

- In what direction does the letter move as seen through the microscope? _____

● While looking through the eyepiece, move the slide slowly from *right to left*.

- In what direction does the letter move when viewed through the microscope? _____

● While looking through the eyepiece, move the slide toward you.

- In what direction does the letter move as seen through the microscope as you move the slide toward you? _____

Part B. Use of the Diaphragm

- Prepare a wet mount of a few strands of absorbent cotton. (Follow the procedure outlined in Investigation 2.)

- Observe the cotton fibers with *low power*. While looking through the microscope, change the amount of light entering the microscope by adjusting the diaphragm.

5. Under what diaphragm setting (maximum, medium, or little light) are the cotton fibers sharpest? _____

- Change to high power and observe the cotton fibers. Again, readjust the amount of light entering the microscope.

6. Under what diaphragm setting (maximum, medium, or little light) do the cotton fibers appear sharpest? _____

All objects viewed under the microscope will require adjustment of light. Many problems associated with microscopic observation can be overcome by adjusting the diaphragm for proper lighting.

Part C. Depth of Field

- Cut a very short length of some black and white thread.

- Add a drop of water to a microscope slide. Cross the two strands to form an X in the water drop before adding a coverslip. Use Figure 3-1 as a guide.

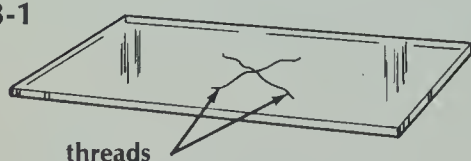
- Locate the strands under low power. Center the slide so you are looking at the point where the strands cross. Adjust the diaphragm for proper lighting.

7. Can both strands be observed clearly at the same time under low power? _____

- Change to high power and observe both strands at the point where they cross.

8. Can both strands be observed clearly at the same time under high power? _____

FIGURE 3-1



The lens system of your microscope allows you to see clearly only one depth at a time under high power. In order to see objects at different depths, do the following:

- Turn the fine wheel adjustment back and forth by a quarter of a turn while looking through the microscope. This movement will give a three-dimensional view of the object. Try this technique while looking at the crossed threads. Using Figure 3-2 as a guide, note that first one strand is in focus, then the other.

FIGURE 3-2



white thread in focus



black thread in focus

Part D. An Aid to Finding Proper Depth

Locating the proper depth of a wet mount is not always easy. Proper depth is especially hard to find when attempting to view moving organisms or when locating objects so small that they cannot be seen on the slide with the unaided eye. It is easy to focus at the wrong depth of the wet mount and waste valuable time looking at the top surface of the coverslip. The following technique will help you locate the proper depth of a wet mount.

- Use a dropper to transfer a drop of pond water to a glass slide.

- Add a hair from your head to the pond water. Add a coverslip.

- Observe the wet mount under low power by first locating the strand of hair. Focus the hair and adjust the light. The slide can now be moved to find organisms in the pond water. No further adjustment is necessary with the coarse adjustment. You are at the proper depth for finding organisms because the hair and organisms are in the same plane.

- Locate organisms in the pond water. Attempt to follow a moving organism if one is present.

Part E. Stains as an Aid to Microscope Work

Many objects observed with a microscope are colorless. Thus, they appear almost transparent and are difficult to see. Stains often are used in microscope work to color objects for easier and more detailed observation. Stains can be added to a wet mount without disturbing the slide.

- With a razor blade, gently scrape the edge of a peeled potato. DO NOT scrape the potato skin. **CAUTION:** *Scrape away from your fingers.*

- Add a drop of water to a glass slide. Mix the potato scrapings with the water. Add a coverslip.

- View the wet mount with low power. You are looking at starch grains.

- Diagram several starch grains in the space provided marked "unstained."

- Remove the slide from the microscope.

- Add a drop of iodine solution to your slide along one edge of the coverslip as shown in Figure 3-3A. Do not get any iodine on top of the coverslip. **CAUTION:** *If iodine spillage occurs, wash with water and call your teacher immediately.*

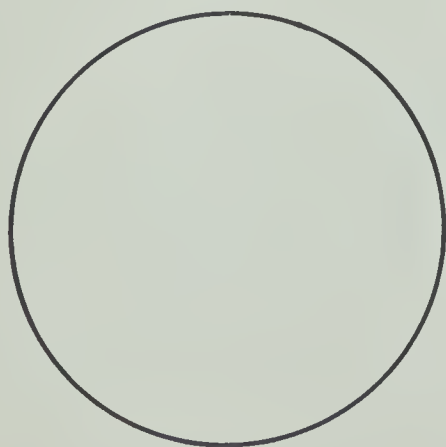
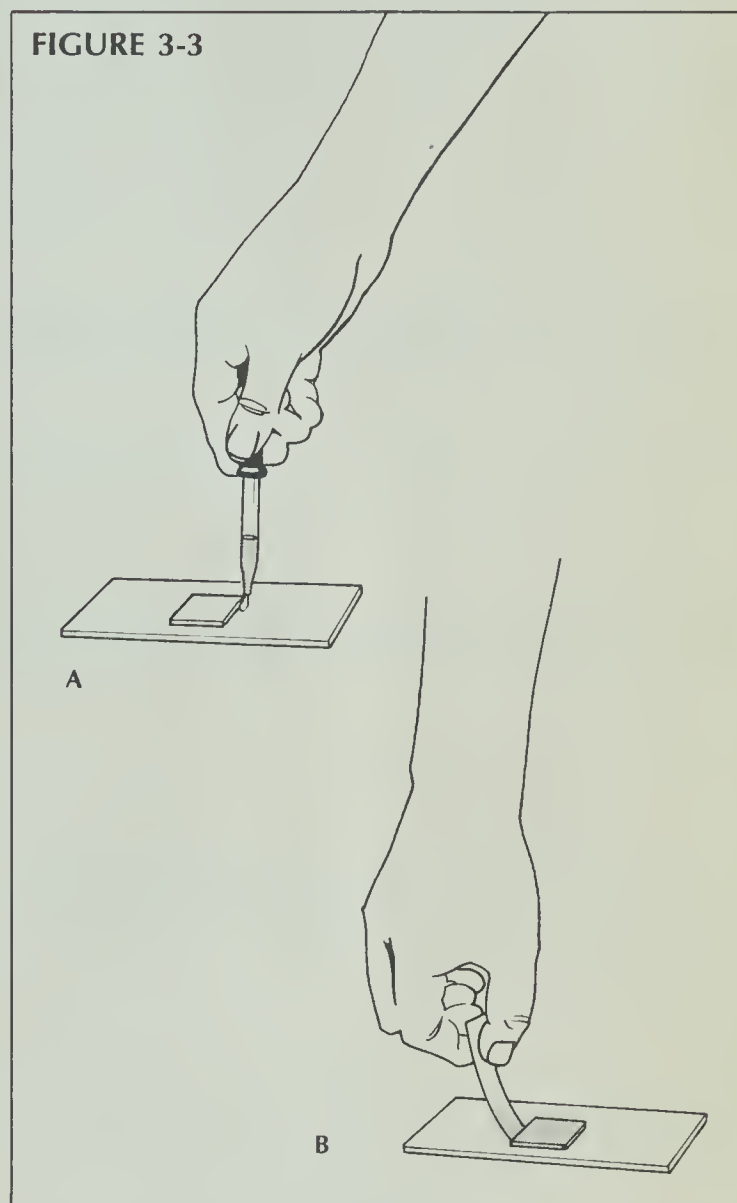
- Place a piece of tissue paper along the edge of the coverslip opposite the iodine solution. Allow the tissue paper to touch the water of the wet mount as shown in Figure 3-3B. Water will soak into the tissue paper, drawing the iodine stain under the coverslip and into contact with the starch grains.

- Observe the stained starch grains with low power.

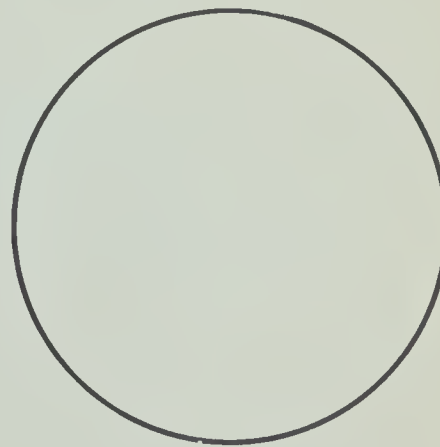
- Diagram several stained cells in the space provided.

9. Briefly describe the value of staining objects to be observed under a microscope. _____

FIGURE 3-3



unstained



stained

Part F. A Comparison of Fields of View

Field of view is the area seen through a microscope. Is the field of view with low power greater than with high power, or are they the same? This exercise will help you answer this question.

- Move the slide to a less crowded area of starch grains. This area is usually near the outer edge of the coverslip.

- Examine the stained starch grains with low power.

10. Count and record the number of grains observed under low power. _____

- Without moving the slide, examine the stained starch grains with high power.

11. Count and record the number of grains observed under high power. _____

12. How do the number of grains observed under low power compare to the number under high power? _____

When using low power, the total area of your field of view is *greater* than when using high power.

Analysis

Answer the following as true or false.

1. Objects viewed under the microscope appear upside down. _____
2. When moving the slide toward the left, objects viewed through the microscope will move toward the left. _____
3. The diaphragm is used to adjust the amount of light entering the microscope. _____
4. All objects in different depths appear in focus at the same time while using high power. _____
5. Stains are used to help make clear objects appear lighter under the microscope. _____
6. Low power shows more area than high power. _____
7. High power shows more detail than low power. _____
8. Observers see about 10 times more area under low power than under high power. _____

How much greater this area is can be calculated by using the numbers on your objectives. For example, if low power is 10X and high power is 40X, divide 40 by 10. The answer is 4. This answer means that the area observed under low power is four times as large as the area observed under high.

13. Calculate the number of times greater low power area is than high power for your microscope. Remember:

$$\frac{\text{High Power Objective}}{\text{Low Power Objective}} = \text{number of times area seen under low power is greater than that seen under high power}$$

Don't confuse total area observed with total magnification. As magnification increases, total area observed decreases.

14. Did you observe more or fewer starch grains under low power as compared to high power? _____

15. Did you observe more or less area under low power as compared to high power? _____

16. Your answers to questions 10 and 11 should show about four times more starch grains viewed under low power as compared to high power. Explain. _____

SOLVING A PROBLEM WITH A SCIENTIFIC METHOD

4

A method by which a scientist solves a problem is called a scientific method. This method usually includes observation, experimentation, interpretation, and hypothesis formation. Scientific method often has been compared to the procedure a detective uses in solving a crime or problem. The following investigation creates a scientific problem for you and asks you to solve it. You will follow a scientific method in attempting to solve the problem.

In this investigation, you will

- (a) use a scientific approach to solve whether or not flasks A and B contain similar or different liquids.
- (b) make careful observations.
- (c) record accurate experimental results.
- (d) use your data (recorded results) as a basis for deciding if the two liquids are similar or different.

Materials

2 Erlenmeyer flasks containing liquids
clock or watch with second hand

2 stoppers (to fit flasks)
beaker

Procedure

Part A. Observation

Accurate observations are a necessary part of any scientific method.

- Examine the two flasks. DO NOT remove the stoppers and DO NOT shake the contents.
- Notice the flasks have been labeled A and B.
- Record in Table 4-1 two or three similarities or differences between the two flasks.

1. (a) Do you think both flasks contain the same liquid? _____

(b) Explain. _____

- 2. Is your answer to question 1 based on experimentation or guessing? _____
- 3. Would scientists guess at answers to questions or would they experiment first? _____
- 4. Are both flasks exactly alike in amounts of liquid? _____

TABLE 4-1. FIRST OBSERVATIONS

SIMILARITIES	DIFFERENCES

5. What gas may be in the upper half of flask A that is not in flask B?_____
6. Is there any direct evidence for your answer to question 5?_____

Part B. Experimentation

In determining if the two liquids are the same or not, a scientist would carry out some experiments. Experimentation is another part of the scientific method.

Experiment 1. What happens if you shake the liquids?

- Give each flask *one hard shake using an up-and-down motion of your hand*. Make sure your thumb covers the stopper as you shake. Use Figure 4-1 as a guide.
 - Observe each flask carefully.
 - Record your observations in Table 4-2. Again, look for similarities and differences.
7. After shaking the flasks, do you think they contain different liquids?_____

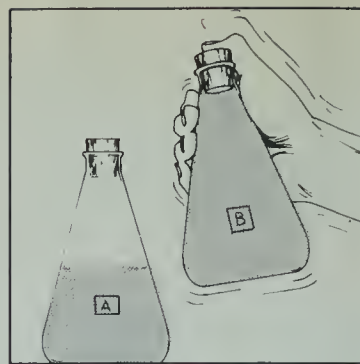


FIGURE 4-1

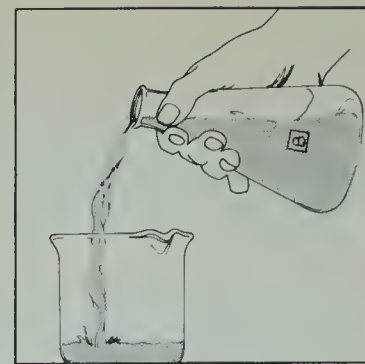


FIGURE 4-2

8. What was present in flask A that may have been responsible for the change in the liquid?_____
- _____
- _____

Experiment 2. What happens if you remove some of the liquid in flask B so it appears like flask A?

- Remove the stopper from flask B and pour out half of the contents into a beaker or other suitable container (Figure 4-2). Make sure that the amount of liquid in flask B is equal to the amount of liquid in flask A. Replace the stopper. Give both flasks *one hard shake using an up-and-down motion of your hand*. Hold stopper in place while shaking.

TABLE 4-2. RESULTS OF EXPERIMENT 1

SIMILARITIES	DIFFERENCES

TABLE 4-3. RESULTS OF EXPERIMENT 2

SIMILARITIES	DIFFERENCES

- Observe each flask carefully.
 - Record any similarities or differences observed in Table 4-3.
9. Do both flasks now appear to contain the same liquid? _____
10. What may have been added to flask B that was not present before? (See question 5.) _____

Experiment 3. What happens if you shake the flasks more than once?

- *Shake each flask hard once with an up-and-down motion.*
 - Note the exact time in seconds after shaking that it takes for each liquid to return to its original condition. Record the time in Table 4-4.
 - *Shake each flask hard twice with an up-and-down motion.*
 - Again record in Table 4-4 the time it takes for the liquids to return to their original conditions.
 - *Shake both flasks hard three times with an up-and-down motion.*
 - Record in Table 4-4 the time it takes for them to return to their original conditions.
11. After one shake, are the two liquids generally "behaving" in a similar way? That is, is the time needed for flasks A and B to return to their original condition about the same? _____
12. After two and three shakes, are flasks A and B generally "behaving" in a way similar to each other? _____

13. Look at your data in Table 4-4.

(a) Does flask A show an increase or decrease in time needed to return to its original condition as the number of shakes increases from one to three?

(b) Does flask B show a similar change?

In any experiment, or in solving any problem by a scientific method, more than one trial is important. Several trials reduce the probability of making errors.

- Run two more trials for each part of Experiment 3. Be sure to keep track of the amount of time needed for the liquids to return to their original conditions.

- Consider your recorded results in Table 4-4 as Trial 1. Record the results of Trials 1, 2, and 3 in Table 4-5.

14. Do three trials give better evidence that flask A is "behaving" in a way similar to flask B after shaking each flask

(a) once? _____

(b) twice? _____

(c) three times? _____

15. Do three trials give better evidence that an increase in time is needed for the liquid to return to its original condition as the number of shakes increases from one to three

(a) for flask A? _____

(b) for flask B? _____

TABLE 4-4. RESULTS OF EXPERIMENT 3

	TIME IN SECONDS TO RETURN TO ORIGINAL CONDITION		
	1 shake	2 shakes	3 shakes
Flask A			
Flask B			

TABLE 4-5. THREE TRIALS OF EXPERIMENT 3									
	TIME IN SECONDS TO RETURN TO ORIGINAL CONDITION								
	1 shake			2 shakes			3 shakes		
Trial	1	2	3	1	2	3	1	2	3
Flask A									
Flask B									

Analysis

Questions 1-4 should help you to make some interpretations of what you have observed. Interpretations are reasonings based on observations and experiments. They are usually the next step in a scientific method.

1. On the basis of your first observations in Part A, could you decide if both flasks contained the same liquid?_____
 2. After performing Experiment 1, could you decide if both flasks contained the same liquid?_____
 3. Which experiment or experiments may have helped you to decide that the liquids in flasks A and B were similar or different?_____
- Explain._____
4. Besides the liquid itself, what else seems to be needed in order for the liquid to change color?

Questions 5-7 should help you to form a hypothesis. In a hypothesis, all facts are joined in an attempt to explain what has been observed.

5. Explain why flask B did not change color when shaken in Experiment 1._____
6. Why must the liquids in the half-filled flasks be shaken in order to produce a color change?_____

7. Why did more shaking increase the amount of time needed for the liquids in flasks A and B to change back to their original color?_____

8. (a) Could you have solved question 1 in Part A by guessing?_____
- (b) Why is experimenting a better method of problem solving than guessing?_____

- (c) What is meant by the phrase "solving a problem by using the scientific method"?_____

USING SI UNITS

How many inches equal one foot? How many feet equal one yard? Almost everybody can answer these questions. But how many yards equal one rod?

Is there any one number that is common for changing inches to feet, feet to yards, or yards to rods? A problem with the English system for measuring is that there is no common number for changing one unit to another. As a result, you may have had difficulty remembering that there are $5\frac{1}{2}$ yards to a rod.

Biologists and other scientists use the SI system of measuring rather than the English system. SI is an abbreviation for the International System of Measurement. SI is a more modern version of the old metric system.

In this investigation, you will

- identify and use SI units of length and volume to measure several objects.
- learn two important rules for converting from one SI unit to another.

Materials

metric ruler
50-mL graduated cylinder
microscope slide

Procedure

Part A. Measuring Length in SI Units

How tall are you? How wide is your classroom? What is the size of your desk top? How long are pine tree needles? Getting answers to these questions involves measurements of distance or length. What unit in the SI system is used to measure length?

- Examine a metric ruler. Starting at the left edge, locate the smallest division or mark. This unit is the millimetre (mm). Ten millimetres are equal to a unit called the centimetre (cm). The ruler will have a longer line and the number 1 marked at the 1 cm length (Figure 5-1).

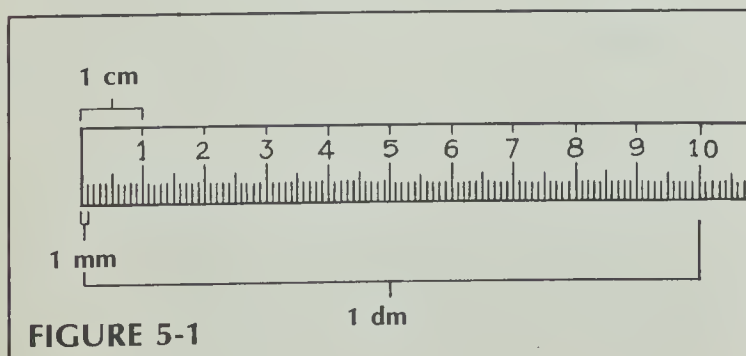


FIGURE 5-1

- How many millimetres equal 1 cm? _____
- How many millimetres equal 3 cm? _____
- What number is used in changing the number of millimetres to centimetres? _____

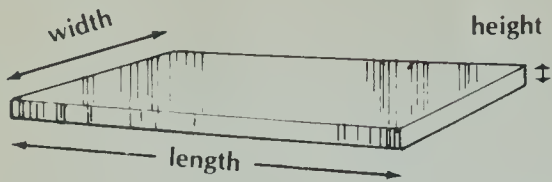
Ten centimetres are equal to one decimetre (dm). Ten decimetres are equal to one metre (m).

- What number is used when changing
 - centimetres to decimetres? _____
 - decimetres to metres? _____

- Measure a microscope slide in millimetres. Use Figure 5-2 as a guide to length, width, and height. Record these values in the column marked "mm" of Table 5-1.

- To convert your millimetre numbers to centimetres, divide the millimetre numbers by 10. Record the length, width, and height of your slide in centimetres. Use the column marked "cm" of Table 5-1.

FIGURE 5-2



● To convert your centimetre numbers to decimetres, divide the centimetre numbers by 10. Record the length, width, and height of your slide in decimetres. Use the column marked "dm" of Table 5-1.

● To convert decimetres to metres, divide decimetres by 10. Record your slide measurements in metres on Table 5-1 in the column marked "m."

TABLE 5-1. MICROSCOPE SLIDE MEASUREMENTS

	mm	cm	dm	m	km
Length					
Width					
Height					

A unit, kilometres, often is used to measure long distances. 1000 metres equal 1 kilometre (km).

● To convert metres to kilometres, divide metres by 1000 (not by 10). Record your slide measurements in kilometres in the column marked "km" of Table 5-1.

5. Can you divide millimetre figures by 100 to change directly to decimetres?_____

6. Can you divide millimetre figures by 1000 to change directly to metres?_____

7. What number do you divide by when changing centimetres to metres?_____

8. As a review, to change

(a) mm to cm, divide by_____.

(b) mm to dm, divide by_____.

(c) mm to m, divide by_____.

(d) mm to km, divide by_____.

(e) cm to m, divide by_____.

(f) cm to km, divide by_____.

● Measure the length and width of your lab table or desk.

● Record these dimensions in metres in Table 5-2. Record your answers in decimals. If your desk or lab table measures 1 m plus 14 cm, record this measurement as 1.14 m. If it measures less than 1 m, such as 83 cm, record this measurement as 0.83 m. Because 1 m equals 100 cm, 83 cm is the same as 83/100 or 0.83 m.

● Convert your metre measurements to decimetres. Do this conversion by multiplying metre figures by 10. Record the decimetre values in the proper column of Table 5-2. Convert your decimetre values in Table 5-2 to centimetres. Do this conversion by multiplying decimetre figures by 10. Record the centimetre values in the proper column of Table 5-2.

TABLE 5-2. LAB TABLE MEASUREMENTS

	m	dm	cm	mm
Length				
Width				

9. What number is used to convert centimetre measurements to millimetres?_____

● To convert your centimetre values to millimetres, multiply centimetre figures by 10. Record the millimetre values in the proper column of Table 5-2.

10. According to Table 5-2, can you multiply metre figures by 100 to change directly to centimetres?_____

11. Can you multiply metre figures by 1000 to change directly to millimetres?_____

12. As a review, to change

(a) m to dm, multiply by_____.

(b) m to cm, multiply by_____.

(c) m to mm, multiply by_____.

(d) cm to mm, multiply by_____.

(e) km to m, multiply by_____.
(Be careful.)

● When converting from one SI unit to another, you must either multiply or divide. Is there any pattern which will always allow you to decide whether to divide or multiply? Yes, there is.

13. (a) What operation is used in Table 5-1 to go from millimetres to centimetres? (Millimetres are small in size, centimetres are larger units in size.)_____

(b) When changing from small SI units to large units, what mathematical operation (multiplying or dividing) is used?_____

14. Which unit is smaller in size:

(a) decimetre or metre?_____

(b) centimetre or kilometre?_____

(c) metre or kilometre?_____

15. (a) When changing from large SI units to smaller units, what mathematical operation (multiplying or dividing) is used?

(b) What operation is used in Table 5-2 to go from metres to centimetres?_____

16. Which unit is larger in size:

(a) kilometre or millimetre?_____

(b) decimetre or millimetre?_____

(c) centimetre or decimetre?_____

When changing from one unit to another, you must remember:

(a) If you are changing from a small unit to a larger unit, you must divide. What number to divide by is determined by what new units are being asked for. For example, if changing millimetres to centimetres, divide by 10; if changing millimetres to decimetres, divide by 100 again.

(b) if you are changing from a large unit to a smaller unit, you must multiply. What number to multiply by is determined by what new units are being asked for. For example, if changing kilometres to metres, multiply by 1000; changing metres to millimetres, multiply by 1000; changing kilometres to centimetres, multiply by 100 000.

The metre is the main unit for measuring length or distance in the SI system. All changes from one unit to another involve a change of 10, or some multiple of 10.

17. Fill in the blanks.

(a) 29 mm = _____ cm

(b) 4 dm = _____ m

(c) 44 dm = _____ cm

(d) 1205 cm = _____ dm

(e) 27 km = _____ m

18. Fill in the blanks.

(a) 103 dm = _____ m

(b) 0.29 dm = _____ mm

(c) 1202 mm = _____ cm

(d) 48 mm = _____ m

(e) 7.2 m = _____ cm

Part B. Measuring Volume in SI Units

How much air do you inhale in one breath? How much water do you normally drink in one day? Can you measure the amount of space occupied by a bean seed? Getting answers to these questions involves the measuring of volume. What unit is used in the SI system to measure volume?

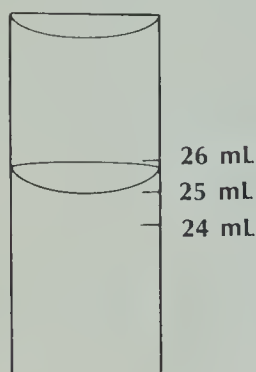
● Examine a graduated cylinder with volume markings of 50 units. Each single line represents a unit of volume called a millilitre (mL). DO NOT confuse this word with millimetre (mm).

● Fill the cylinder with water to the 25 mL line and place the cylinder on your desk.

● Compare the level of water in your cylinder with Figure 5-3. On close examination, the water rides up along the edges of the cylinder. The proper reading of volume is judged by the bottom level of water.

Adjust the volume of water if necessary so that it is exactly 25 mL. Convert your 25 mL volume to centilitre (cL) units. Use the same rule as established for length units. Are you changing from small to large units? If yes, then divide.

FIGURE 5-3



● Fill in Table 5-3 for centilitres, decilitres (dL), and litres (L). There are 10 centilitres in a decilitre, and 10 decilitres in a litre.

TABLE 5-3. VOLUME OF WATER IN CYLINDER

	mL	cL	dL	L
Volume				

19. Complete the following chart based on the numbers filled in for you. "kL" stands for kilolitre.

	kL	L	dL	cL	mL
Volume	.032	32			

The litre (L) is the main unit for measuring volume in the SI system.

20. Fill in the blanks:

(a) 1.4 L = _____ mL

(b) 5520 mL = _____ cL

Analysis

1. What SI units studied can be used for measuring length? _____

2. What SI units studied can be used for measuring volume? _____

3. Why is it easier to convert metres to centimetres or millimetres than to convert miles to feet or inches? _____

4. Give the symbol for each of the following units.

millimetre = _____ kilolitre = _____ centimetre = _____ litre = _____

5. What units are represented by each of the following symbols?

dL = _____ km = _____ dm = _____ cL = _____

6. Circle the larger unit in each of the following pairs.

(a) kilolitre or litre (c) decimetre or millimetre (e) millimetre or kilometre

(b) centimetre or metre (d) centimetre or millimetre (f) centilitre or decilitre

7. Which mathematical process (multiplying or dividing) is used to change

(a) centilitres to litres? _____

(b) centilitres to decilitres? _____

(c) metres to centimetres? _____

(d) millimetres to metres? _____

CARBOHYDRATES: CHEMISTRY AND IDENTIFICATION

Today, scientists use a combination of biology and chemistry for their understanding of life and life processes. Thus, an understanding of some chemistry of living things is necessary. Carbohydrates make up a large group of chemical compounds found in cells. Carbohydrates are an energy source or are used in making cell structures.

In this investigation, you will

- learn how to write a molecular formula for several carbohydrates.
- learn how to read a structural formula for several carbohydrates.
- use models to construct the three main types of carbohydrates.
- identify the three main types of carbohydrates by using chemical tests.
- test different food samples to determine what type of carbohydrate they are.

REMEMBER: Models do not represent the actual three-dimensional shapes of the molecules. Models serve to help you learn how smaller molecules can be grouped into larger, more complex molecules.

Materials

paper models
scissors
test tubes
test tube holder
glass marking pencil or labels
Benedict's solution
iodine solution

droppers
hot plate
water
beaker (Pyrex)
monosaccharide solution
disaccharide solution

polysaccharide solution
apple juice
oat solution
table sugar solution
honey solution
powdered sugar solution

Procedure

Part A. Water Model

- Examine the chemical formula of water, H_2O .

Question: What elements make up water?

Answer: H represents the element hydrogen. O represents the element oxygen. Water is made up of hydrogen and oxygen.

Question: What does the number 2 following H tell you?

Answer: The number 2 represents the number of atoms of hydrogen. A number, called a subscript, following a chemical symbol indicates the number of atoms of that particular element.

Question: Why does the oxygen symbol (O) not have a subscript?

Answer: There is only one atom.

Question: How many molecules of water are represented by the formula H_2O ?

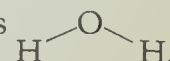
Answer: One molecule is represented. The number of molecules is indicated by a number to the left of the formula. No number indicates one molecule.

Question: What is a molecular formula? What is the molecular formula of water?

Answer: A molecular formula shows the total number of atoms for each element in a molecule. The molecular formula of water is H_2O .

Question: What is a structural formula? What is the structural formula of water?

Answer: A structural formula attempts to show the three-dimensional organization of the molecule. The structural formula of water is

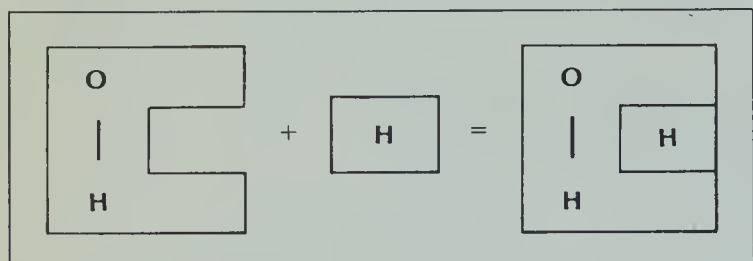


Question: What do the lines between O and H in the structural formula of water represent?

Answer: These lines represent chemical bonds or points of attachment between the atoms.

Question: What is one way water can be represented as a paper model?

Answer: One way water may be represented is shown below. We will use this way of representing water throughout the study of different chemical compounds found in living systems.



Part B. Carbohydrate Models

There are three different groups of carbohydrates. They are called monosaccharides, disaccharides, and polysaccharides. "Saccharide" means sugar.

Group 1. Monosaccharides (single molecule sugars)

A single molecule sugar is called a monosaccharide. The prefix "mono-" means one. However, the one molecule can have different shapes due to a different arrangement of atoms. Three monosaccharides are glucose, fructose, and galactose.

● Examine the structural formulas of these three sugars (Figure 6-1) and answer questions 1 to 6.

1. What three chemical elements are present in the three monosaccharides shown? (NOTE: The letter "C" stands for carbon, "H" stands for hydrogen, and "O" stands for oxygen.)

2. How many atoms of carbon are present in a molecule of

glucose? _____

fructose? _____

galactose? _____

3. Add subscripts to the following to indicate the proper molecular formula. Fill in the blanks by counting the total number of carbon, hydrogen, and oxygen atoms in each molecule.

glucose C__H__O__

fructose C__H__O__

galactose C__H__O__

4. Are there two times as many hydrogen atoms as oxygen atoms in a molecule of:

glucose? _____

fructose? _____

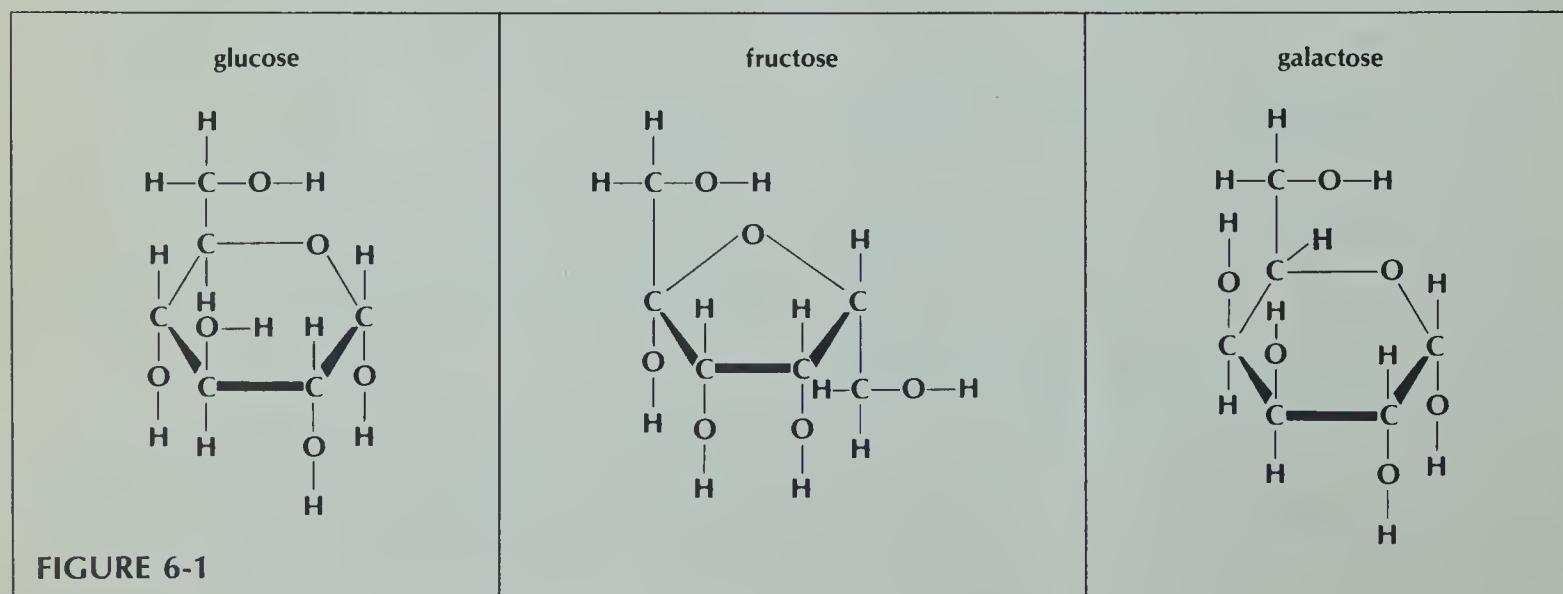
galactose? _____

5. Are there two times as many hydrogen atoms as oxygen atoms in a molecule of water?

● Compare the structural formula of glucose to fructose.

6. (a) Are they exactly the same in shape?

(b) Are they both monosaccharides?



Group 2. Disaccharides (double molecule sugars)

Two monosaccharide sugar molecules can join chemically to form a larger carbohydrate molecule called a double sugar, or disaccharide. The prefix "di-" means two. By chemically joining a glucose molecule with a fructose molecule, a double sugar called sucrose is produced.

Use the page of paper models given to you by your teacher to complete this section.

● Cut out a model of one glucose and one fructose molecule. **CAUTION:** *Always be extremely careful with scissors. Cut along solid lines only.* Attempt to join the two molecules like puzzle pieces.

7. Do the glucose and fructose fit together easily to form a sucrose molecule? _____

● In order to join the molecules, remove an -OH end from one molecule and an -H end from another. Cut along dotted lines.

8. Does removing the -H and -OH ends now allow the molecules to fit together easily?

9. The -H and -OH ends that were removed can also fit together with each other to form a molecule. This new molecule has a molecular formula of _____ and is called _____.
10. Write the molecular formula for sucrose by adding together the molecular formulas for glucose and fructose and then subtracting water, H_2O . (Use structural formulas for this step, not the models.)

Different disaccharide molecules can be made by joining other monosaccharides in different combinations. By chemically joining a glucose molecule with another glucose molecule, a double sugar called maltose is formed.

● Cut out and attempt to join the two new glucose model molecules like puzzle pieces.

11. What must be removed from the glucose model molecules so that they easily fit together? _____

12. Write the molecular formula for maltose. (See question 10.) _____

13. (a) How does the molecular formula for sucrose compare to maltose? _____

- (b) Are there two times as many hydrogen atoms as oxygen atoms in a disaccharide?

- (c) How many monosaccharide molecules are needed to form one sucrose molecule?

- (d) How many monosaccharide molecules are needed to form one maltose molecule?

Group 3. Polysaccharides (many molecule sugars)

Just as double sugars were formed from two single sugar molecules, polysaccharides are formed when many single sugars are joined chemically. The prefix "poly-" means many. Starch, glycogen, and cellulose are the three most common polysaccharides in biology. They consist of long chains of glucose molecules joined.

● Construct a starch molecule by joining three glucose molecules. This model will represent only a small part of a starch molecule because starch consists of hundreds of glucose molecules.

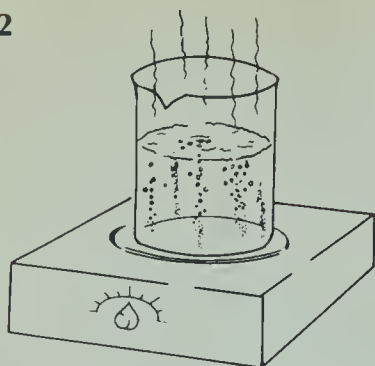
14. What must be removed from the glucose model molecules in order to have them easily fit together? _____

The molecular formula for a polysaccharide is written as $(C_6H_{10}O_5)_n$. The n equals the number of times the $C_6H_{10}O_5$ group is repeated. You can see this group as the middle glucose of your model. **REMEMBER:** The -H and -OH ends of the middle molecule are missing.

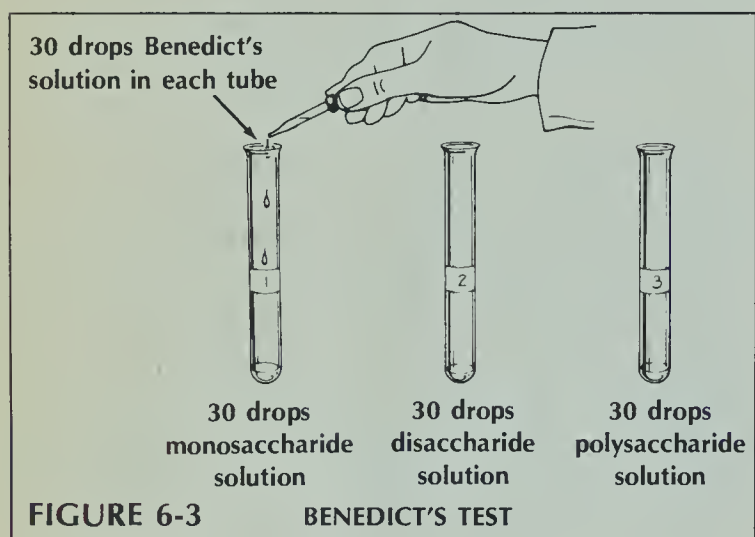
Part C. Identification of Carbohydrates**I. Chemical Tests on Known Carbohydrates****Benedict's Test**

● Fill a 500 mL beaker half full of water. Bring the water to a boil on a hot plate. The boiling water is called a hot water bath (Figure 6-2). **CAUTION:** *Water is very hot.*

FIGURE 6-2



- Number three clean test tubes one to three. Using Figure 6-3 as a guide and a clean dropper for each tube, add the following:
 Tube 1—30 drops of monosaccharide solution
 Tube 2—30 drops of disaccharide solution
 Tube 3—30 drops of polysaccharide solution



- Add 30 drops of Benedict's solution to each tube.

CAUTION: If Benedict's solution spillage occurs, rinse with water and call your teacher.

- Place the three test tubes into the hot water bath for five minutes.

- Use a test tube holder to remove the tubes from the hot water bath.

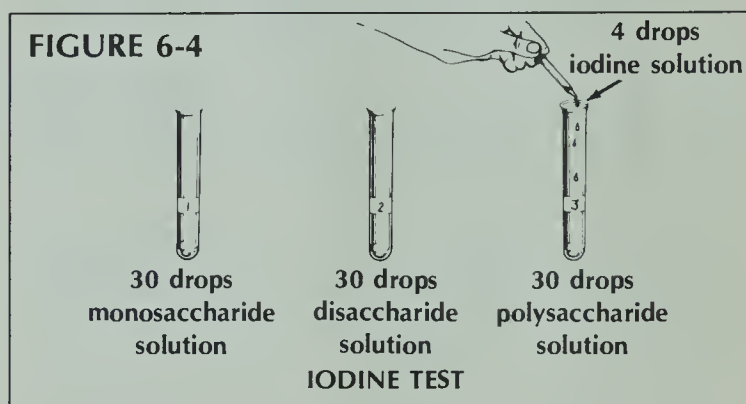
CAUTION: Water and test tubes are very hot. Handle test tubes only with a test tube holder.

- Observe any color changes in the solutions. **NOTE:** A color change may or may not occur when Benedict's solution is added to a carbohydrate and then heated. A change from blue to green, yellow, orange, or red occurs if a monosaccharide is present. The original blue color will remain after heating if a disaccharide or polysaccharide is present.

- Record in Table 6-1 the color of the solutions in the tubes in the column marked "Benedict's Color After Heating."

Iodine Test

- Number three clean test tubes one to three. Using Figure 6-4 as a guide and a clean dropper for each tube, add the following:
 Tube 1—30 drops of monosaccharide solution
 Tube 2—30 drops of disaccharide solution
 Tube 3—30 drops of polysaccharide solution



- Add 4 drops of iodine solution to each tube. **CAUTION:** If iodine spillage occurs, rinse with water and call your teacher immediately.

- Mix the contents of each tube by gently swirling.

- Record in Table 6-1 the color of the solutions in the three tubes in the column marked "Iodine color." **NOTE:** A color change may or may not occur when iodine solution is added to a carbohydrate. A change from its original rust color to deep blue-black occurs if a polysaccharide is present. The original color of the carbohydrate remains if a disaccharide or monosaccharide sugar is present.

TABLE 6-1. RESULTS OF TESTS WITH KNOWN CARBOHYDRATES

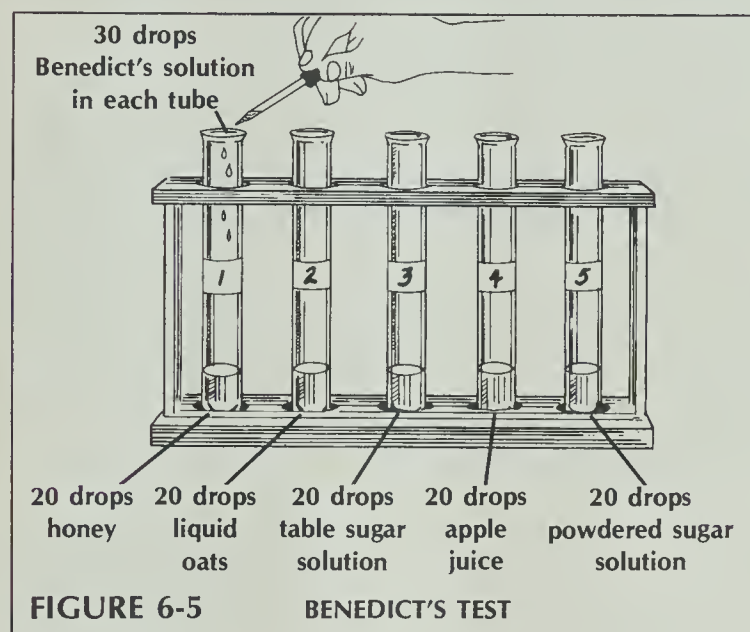
TUBE NUMBER	CARBOHYDRATE TYPE	BENEDICT'S COLOR AFTER HEATING	IODINE COLOR
1	Monosaccharide		
2	Disaccharide		
3	Polysaccharide		

II. Chemical Tests on Unknown Carbohydrates

Having tested known carbohydrates, you are now ready to test some unknown substances. By comparing results of the Benedict's and iodine tests in Table 6-1, you should be able to classify known substances as either monosaccharides, disaccharides, or polysaccharides.

- Number five clean test tubes 1 to 5. Using Figure 6-5 as a guide and a clean dropper for each tube, add the following:

tube 1—20 drops of honey
 tube 2—20 drops of liquid oats
 tube 3—20 drops of table sugar solution
 tube 4—20 drops of apple juice
 tube 5—20 drops of powdered sugar solution

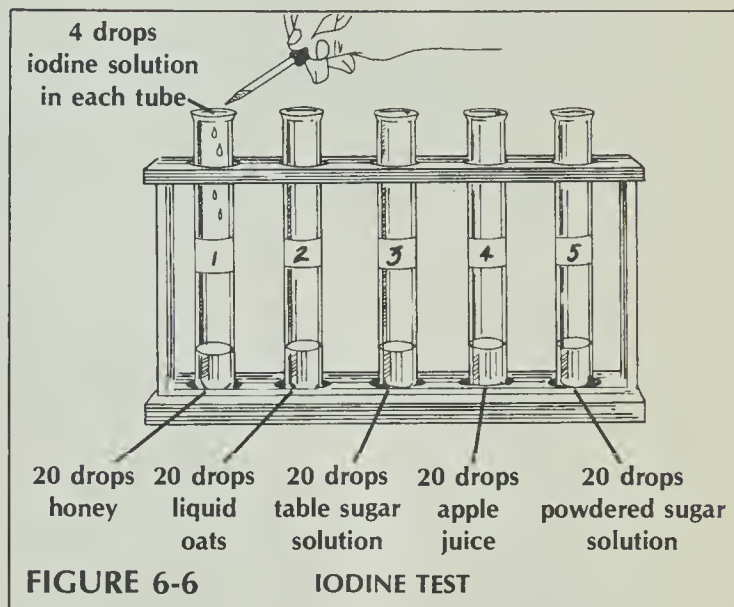


- Add 30 drops of Benedict's solution to each test tube.

- Place all five test tubes into a hot water bath for five minutes.

- Remove the test tubes from the bath with a test tube holder and note any color changes. Record the color of the solutions in Table 6-2.

- Using Figure 6-6 as a guide, prepare five more test tubes containing the same substances just used (honey, oats, and so on). *Do not add Benedict's solution.*



- Add 4 drops of iodine solution to each tube and mix by swirling.
- Note any color changes and record in Table 6-2.

On the basis of your results, classify each carbohydrate as a monosaccharide, disaccharide or polysaccharide and record answers in Table 6-2.

TABLE 6-2. RESULTS OF TESTS WITH UNKNOWN CARBOHYDRATES

CARBOHYDRATE	BENEDICT'S COLOR	IODINE COLOR	TYPE OF CARBOHYDRATE
Honey			
Oats			
Table sugar			
Apple			
Powdered sugar			

Analysis

Use your results from Parts A and B to answer questions 1 to 5.

1. Name the three categories of carbohydrates studied in this investigation. _____

2. What three elements are present in all carbohydrates?

3. Give two examples each of sugars that are
 - (a) monosaccharides. _____
 - (b) disaccharides. _____
 - (c) polysaccharides. _____
4. (a) How many times larger is the number of hydrogen atoms than oxygen atoms in all carbohydrates?

- (b) In water? _____
5. "Mono-" means one, "di-" means two, and "poly-" means many. Why are these terms used in describing the three types of sugars? _____

Use your results from Part C to answer questions 6 to 9.

6. How can you tell by using Benedict's and iodine solutions if a sugar is a
 - (a) monosaccharide? _____
 - (b) disaccharide? _____
 - (c) polysaccharide? _____
7. A certain sugar has no change in color when tested with Benedict's solution.
 - (a) Can you tell what type of saccharide it is? _____
 - (b) Explain: _____

8. A certain sugar has a color change in Benedict's solution.
 - (a) Can you tell what type of saccharide it is? _____
 - (b) Explain: _____

9. Give an example of a food that is a
 - (a) monosaccharide. _____
 - (b) disaccharide. _____
 - (c) polysaccharide. _____

PROTEINS: CHEMISTRY AND IDENTIFICATION

7

Living things are made up of many different chemical molecules. One important group of chemical molecules is proteins. Proteins make up the bulk of all solid material within your body and the bodies of other animals. Your muscle, skin, hair, and inside organs are largely protein. Proteins are essential for body growth and repair. They also make up some hormones which function in chemical control in the body.

In this investigation, you will

- learn how to recognize molecular formulas for small molecules called amino acids.
- use models of different amino acids to construct a protein molecule.
- use chemical tests to determine if protein is or is not present in different substances.

Materials

paper models
scissors
dropper
glass marking pencil or labels
test tubes
test tube rack (or tin can)
nitric acid
fingernail clippings
egg white (hard-boiled)
absorbent cotton
dog hair (white)
cream cheese

Procedure

Part A. Models of Protein

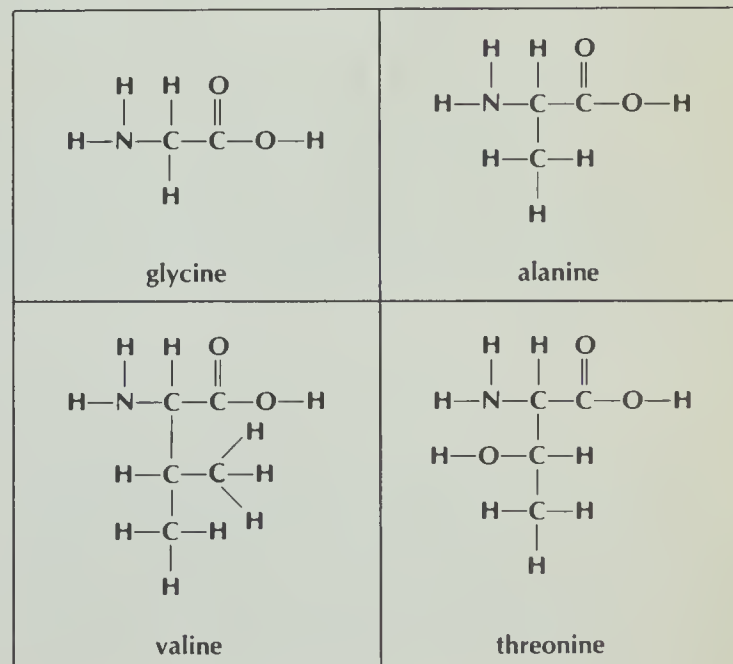
I. Amino Acids, Building Blocks of Protein

Proteins are complex molecules made up of smaller molecules called amino acids. There are about twenty different amino acids found in nature. The element nitrogen (N) is present in all amino acids.

Examine the structural formulas of the four representative amino acids shown in Figure 7-1.

- Name the four elements present in these amino acids.

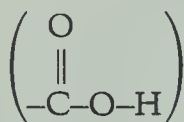
FIGURE 7-1



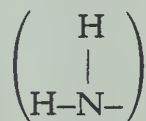
2. What is the molecular formula for the amino acid (a) glycine? C—H—O—N—
 (b) alanine? C—H—O—N—
 (c) valine? C—H—O—N—
 (d) threonine? C—H—O—N—

3. How do the molecular formulas for all the amino acids differ? _____

Note the upper right corner of each amino acid. These ends have a special arrangement of carbon, oxygen, and hydrogen atoms. This end arrangement is called a carboxyl group and looks like this:



4. Circle the carboxyl group on each structural formula in Figure 7-1. Note the upper left corner of each amino acid. These ends have a special arrangement of nitrogen and hydrogen atoms. The end arrangement is called an amino group and looks like this:



5. Use dashed lines to circle the amino groups on the structural formulas in Figure 7-1.
 6. In lab 6, you studied carbohydrates.
 (a) Do carbohydrates have carboxyl groups?

 (b) Do carbohydrates have amino groups?

 7. How does the number of hydrogen atoms compare to the number of oxygen atoms in each amino acid? _____

II. Combining Amino Acids to Form Protein

Amino acids are not protein molecules. They are only the "building blocks" of protein. Several amino acids must be chemically joined in a chain to form a protein molecule. We can show how amino acids join by using models.

Use the paper models given to you by your teacher to complete this section.

- Cut out the four amino acid models. **CAUTION:** *Always be extremely careful with scissors. Cut along the solid lines only.* Attempt to join the amino acids.

8. Can the amino acid models easily join to form a protein molecule? _____

- Join the molecules by removing as many —OH groups and —H groups as needed from the amino acids. All four amino acid molecules can be joined in this manner to form a protein. Join them in the order valine—threonine—alanine—glycine.

- Join the leftover —OH and —H ends.

9. What chemical substance is formed when the —OH's and —H's are joined? _____

10. How many molecules of water are formed when four amino acids join? _____

11. What chemical compound is formed when the four amino acids are joined? _____

12. Describe the difference between an amino acid molecule and a protein molecule.

There are thousands of different proteins in living organisms. What makes each protein different is the order, number, kind, and arrangement in space of amino acids joined. You only assembled four amino acids into a protein using a specific order.

13. Construct two proteins different from the one you made above. List the order of amino acids here:

(a) _____

(b) _____

Part B. Identification of Proteins

- Number five clean test tubes 1 to 5. Place them in a test tube rack. Using Figure 7-2 as a guide, add the following substances to each test tube:

- tube 1—fingernail clippings
 tube 2—egg white, hard-boiled
 tube 3—absorbent cotton
 tube 4—dog hair, white
 tube 5—cream cheese

- Add 5 drops of nitric acid to each test tube.

CAUTION: Nitric acid is harmful to skin and clothing. Rinse with water if spillage occurs. Call your teacher.

The test used to identify protein is technically called the xanthoproteic test. A substance containing protein will turn yellow when nitric acid is added to it. No color change to yellow indicates that the substance being tested has no protein.

- Wait several minutes. Then record the color of the items placed in each tube in Table 7-1.
- On the basis of the xanthoproteic test, indicate in the last column of the table if the substances tested do or do not contain protein.

FIGURE 7-2

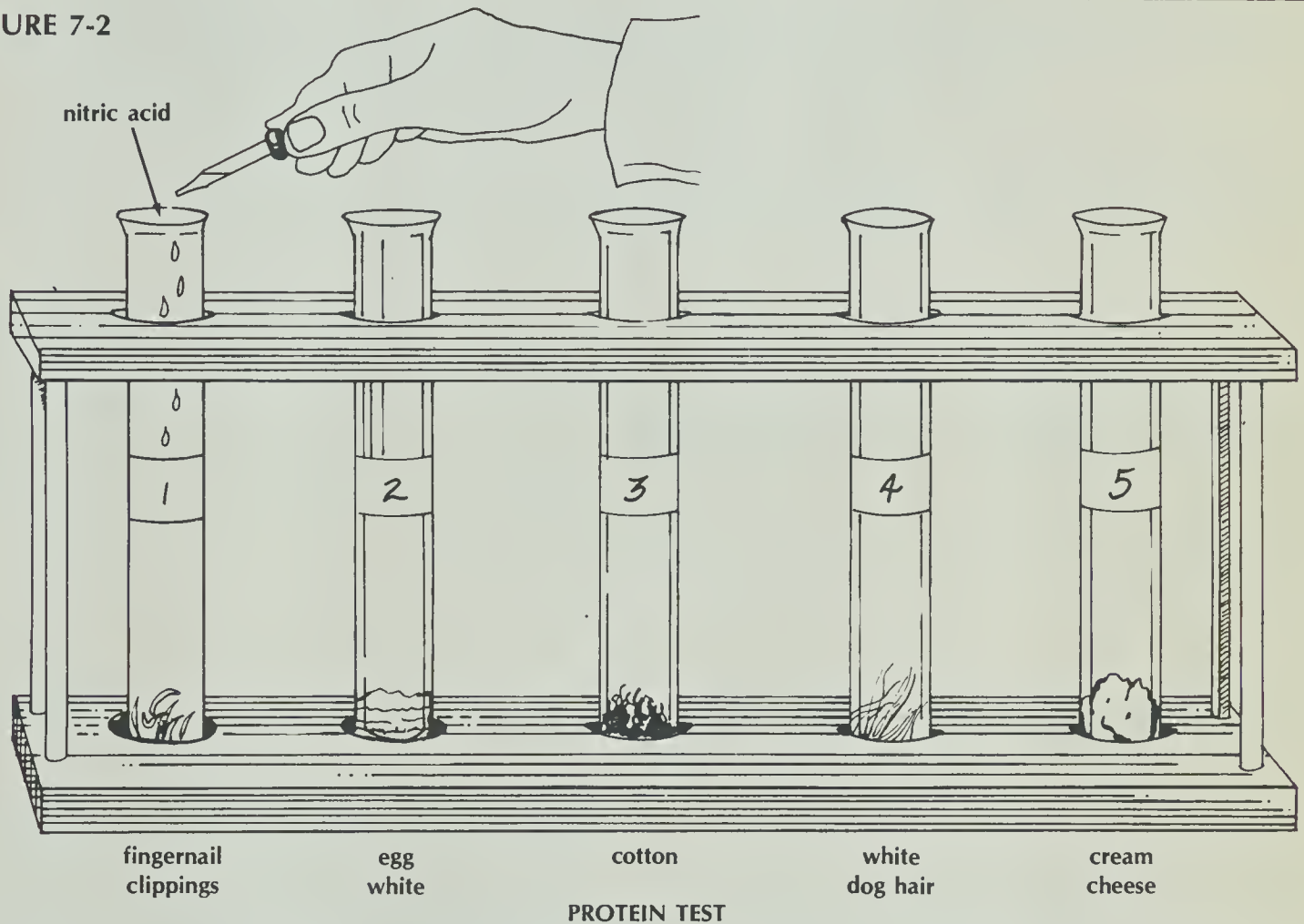


TABLE 7-1. TESTING SUBSTANCES TO DETERMINE IF PROTEINS ARE PRESENT

SUBSTANCE	COLOR CHANGE DUE TO NITRIC ACID	SUBSTANCE TESTED IS A PROTEIN (ANSWER YES OR NO)
Fingernail		
Egg white		
Cotton		
Dog hair		
Cream cheese		

Analysis

Use your results from Part A to answer questions 1-4.

1. Name the four chemical elements present in the amino acids studied (and in all amino acids).

2. Name the two special end groups present in amino acids. _____

3. Explain how a protein molecule is formed in living organisms. _____

4. Explain how one protein differs from another protein. _____

Use your results from Part B to answer questions 5-9.

5. Describe how to tell if a substance is a protein by using the xanthoproteic test. _____

6. (a) List those substances tested that were protein. _____

- (b) List those substances tested that were not protein. _____

7. Nitric acid stains skin yellow. Explain why. _____

8. Using what you have learned about proteins, decide which of the following substances are protein. Place a checkmark on the line next to each substance which is protein.

(a) hamburger _____ (e) liver _____

(b) chicken _____ (f) human hair _____

(c) peanut oil _____ (g) stomach _____

(d) maple syrup _____ (h) 207 amino acids joined _____

9. In Latin, the word "xantho" means yellow, and "proteic" means protein. Why is "xanthoproteic" a meaningful word to use when describing the chemical test used for identifying a protein?

FATS: CHEMISTRY AND IDENTIFICATION

8

Fats are present in living organisms. These chemicals make up certain parts of your body. Fats are often stored when present in excess and also serve as an energy source. Fats are an important part of our diet.

In this investigation, you will

- learn that all fat molecules are made up of two kinds of smaller molecules, glycerol and fatty acids.
- use structural formulas and models of glycerol and fatty acids to determine how these molecules join to form fat molecules.
- learn how to use the solubility test to tell if a substance is a fat.
- learn how to use the brown paper test to tell if a substance is a fat.

Materials

scissors
paper models
clock or watch with second hand
dropper
glass marking pencil or labels

test tubes
test tube rack
olive, corn, or peanut oil
water
brown paper

unknown substance X
unknown substance Y
unknown substance Z
lighter fluid
test tube stoppers—2

Procedure

Part A. Models of Fats

To better understand the chemistry of fats, it is helpful to study first the small molecules which join to make up fats. Fat molecules are made up of two small "building blocks," or chemical molecules. These molecules are called glycerol and fatty acids.

Glycerol

Figure 8-1 shows the structural formula of glycerol.

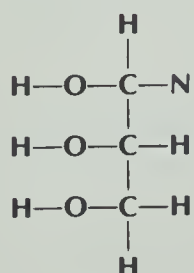


FIGURE 8-1

glycerol

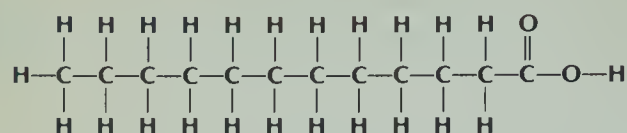
- What elements are present in glycerol?

- Are there any elements in glycerol that are not in carbohydrates? _____
- What is the molecular formula for glycerol? (Add the number of atoms of each element and record the totals.) C__ H__ O__
- Are there two times as many hydrogen atoms as oxygen atoms in glycerol? _____

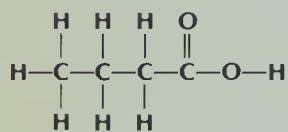
Fatty Acids

The second kind of molecule which is part of a fat is a fatty acid. Many different fatty acids exist, but all are similar in several ways. Butyric acid, caproic acid, and lauric acid are examples of fatty acids. Figure 8-2 shows the structural formulas for these three fatty acids.

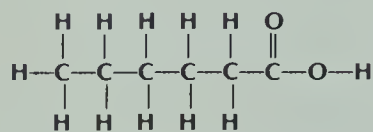
FIGURE 8-2



lauric acid



butyric acid



caproic acid

- Examine the structural formulas for these three molecules.

5. What elements are present in all fatty acids?

6. (a) What is the molecular formula for butyric

fatty acid? $\text{C}_\text{H}_\text{O}_\text{}$

(b) What is the molecular formula for caproic

fatty acid? $\text{C}_\text{H}_\text{O}_\text{}$

(c) What is the molecular formula for lauric

fatty acid? $\text{C}_\text{H}_\text{O}_\text{}$

7. How do the number of hydrogen atoms compare to the number of oxygen atoms in

each fatty acid? _____

8. How many oxygen atoms are present in each

fatty acid? _____

9. Note the end of butyric acid containing the oxygen atoms. This special end arrangement of carbon, hydrogen, and oxygen is called a

carboxyl group $\left(\begin{array}{c} \text{O} \\ || \\ -\text{C}-\text{O}-\text{H} \end{array} \right)$. Is the carboxyl

group present in all fatty acids shown? _____

10. (a) List a similarity between glycerol and fatty acids. _____

(b) Do fatty acids and glycerol both contain a carboxyl group? _____

Combining Glycerol and Fatty Acids to Form Fats

A fat molecule consists of one glycerol molecule and three fatty acid molecules joined.

- Cut out the glycerol and fatty acid paper model molecules given to you by your teacher. **CAUTION:** Always be extremely careful with scissors. Cut along the solid lines only. Attempt to construct a fat molecule.

11. Will the fat molecule fit together as pieces in a puzzle? _____

- Remove three $-\text{OH}$ ends from the glycerol molecule and three $-\text{H}$ ends from the fatty acids. Now join the molecules to form a fat.

12. (a) How many glycerol molecules are needed

to form a fat molecule? _____

(b) How many fatty acid molecules are needed

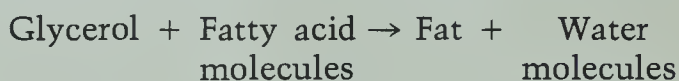
to form a fat molecule? _____

- Join the leftover $-\text{H}$ and $-\text{OH}$ ends from your models.

13. What chemical substance is formed when the

$-\text{H}$ and $-\text{OH}$ ends are joined? _____

Production of a fat molecule is a chemical reaction. A chemical shorthand way of expressing the formation of a fat is as follows:



14. How many water molecules are formed when

one fat molecule is produced? _____

Many fats exist in living things. The wide variety of fats are formed by different combinations of fatty acid molecules.

15. A change in the type of fatty acid results in a different type of a fat molecule. What mole-

cule remains unchanged in all fats? _____

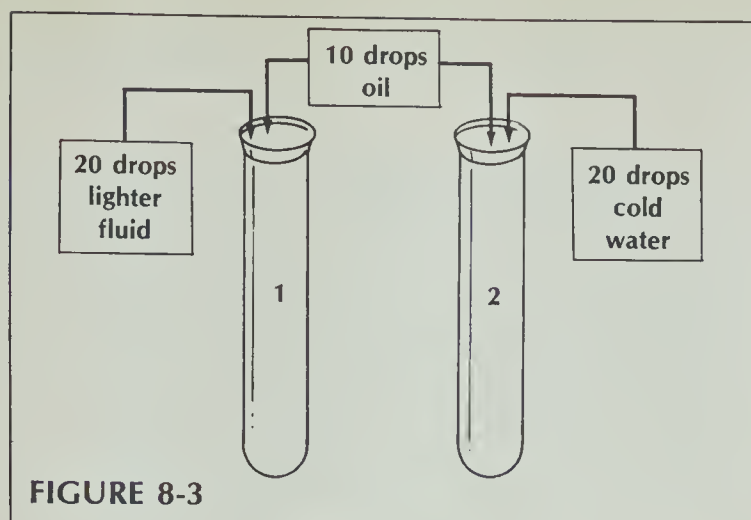
Part B. Identification of Fats

Two different tests can be used to determine the presence of a fat, the solubility test and the brown paper test.

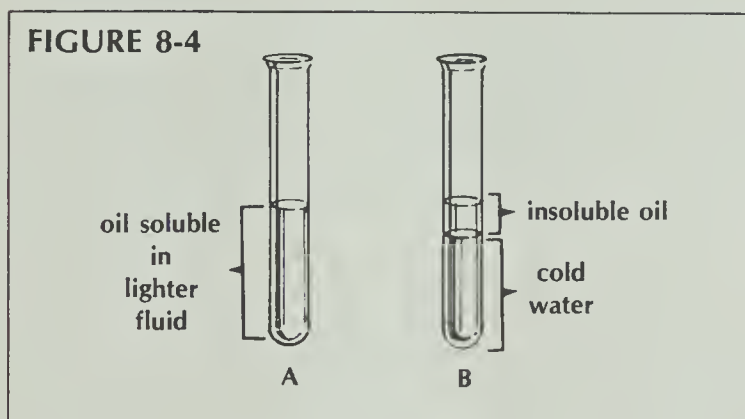
Solubility Test on Known Fats

- Label two test tubes one and two.

- Use Figure 8-3 as a guide to filling your test tubes. **CAUTION:** Lighter fluid is flammable. Extinguish all flames in the laboratory before proceeding. Avoid breathing fumes.



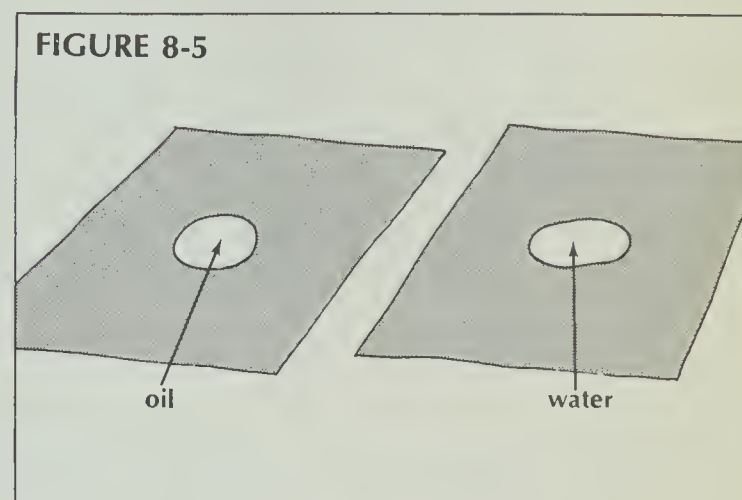
- Mix contents of each tube by placing a stopper over the opening of each tube. Place your thumb over the stopper and shake each tube 10 times.
- Wait one minute.
- Examine and compare both tubes. Fats are soluble in lighter fluid. Soluble means that they dissolve or mix. The liquid in the tube should look like Figure 8-4A in which only one liquid is seen.
- Fats are not soluble in cold water. They do not dissolve or mix. Two layers will be seen as shown in Figure 8-4B.



- Record in Table 8-1 how the oil appears when mixed with lighter fluid and cold water.

Brown Paper Test for Fats

- On separate pieces of brown paper, rub one drop of oil and one drop of water (Figure 8-5). Oil is a fat. Water is not.



- Allow the paper to dry for a few minutes.
- Hold the paper toward light. If light passes through, a translucent (semitransparent) spot has formed.
- Examine the pieces of paper to check for a translucent spot. Record in Table 8-1 how fats and water appear when spotted on brown paper. Fats should give a translucent spot, water should not.

Testing Unknown Substances for Fats

- Perform the lighter fluid solubility and brown paper tests on each of the following substances:

- substance X
- substance Y
- substance Z

NOTE: Use very small amounts of X, Y, and Z if they are not liquid.

- On the basis of your observations, indicate in the last column of Table 8-2 whether or not each substance contains fats.

TABLE 8-1. RESULTS OF TESTS ON FATS

TEST	RESULTS
Fats mixed with lighter fluid	
Fats mixed with cold water	
Fats rubbed on brown paper	
Water rubbed on brown paper	

TABLE 8-2. TESTING UNKNOWN SUBSTANCES FOR FATS (ANSWER YES OR NO)

	TEST			RESULTS
SUBSTANCE	SOLUBLE IN		TRANSLUCENT SPOT FORMED ON PAPER	FAT PRESENT
	LIGHTER FLUID	WATER		
X				
Y				
Z				

Analysis

Use your results from Part A to answer questions 1 to 3.

1. Name the types of molecules and number of each type needed to form a fat molecule. _____

2. List two ways that a fatty acid molecule differs from glycerol. _____

3. Complete the following chart by using "yes" or "no" answers.

TABLE 8-3. SUMMARY OF GLYCEROL, FATTY ACIDS, AND AMINO ACIDS

	GLYCEROL	FATTY ACIDS	AMINO ACIDS
Carbon present			
Hydrogen present			
Oxygen present			
Nitrogen present			
Double the amount of hydrogen as oxygen			
Has a carboxyl group			
Has an amino group			
Molecules join to form fats			
One molecule loses 3 OH ends			

Use your results from Part B to answer question 4.

4. Explain why grease on clothing will not come out with cold water. _____

PROOF OF ENZYME ACTION

Enzymes are special proteins that exist in all living systems. These proteins speed up chemical changes that would take much longer to occur if they were not present. Starch is a polysaccharide made up of many glucose (a monosaccharide) molecules joined together in a long chain. It cannot be broken down quickly or easily into molecules of glucose. If the proper enzyme is added to starch however, it will greatly speed up this chemical reaction and change starch to glucose. An enzyme which can change starch to glucose is present in your saliva. It is called salivary amylase.

In this investigation, you will

- use iodine to test for the presence of starch.
- use Benedict's solution to test for the presence of glucose.
- look for evidence of enzyme action by testing a starch solution to which salivary amylase (an enzyme) has been added.

Materials

hot plate
beaker (Pyrex)
water
iodine solution

starch solution
Benedict's solution
dropper
glass marking pencil

saliva
test tubes
test tube holder

Procedure

Part A. Testing the Properties of Starch

- Half fill a small beaker with water. Place it on a hot plate and bring the water to a boil. This set up is a hot water bath. **CAUTION:** *Water is very hot. Do not handle hot plate or hot glass with unprotected hands.*

- Label two clean tubes as shown in Figure 9-1.
- Use Figure 9-1 as a guide to filling the test tubes.

CAUTION: *If iodine or Benedict's solution spillage occurs, rinse with water and call your teacher immediately.*

- Heat *only* tube S-B in the hot water bath for 5 minutes (Figure 9-2). **CAUTION:** *Test tube is very hot. Handle only with test tube holder.*

- After heating tube S-B, record the color of the solutions in the two tubes. Use the first column of Table 9-1. **NOTE:** When iodine is added to the tube, you may see either a deep blue, a light blue, or no color change. A deep blue color indicates much starch is present. A light blue color indicates the presence of some starch. No blue color indicates the absence of starch.

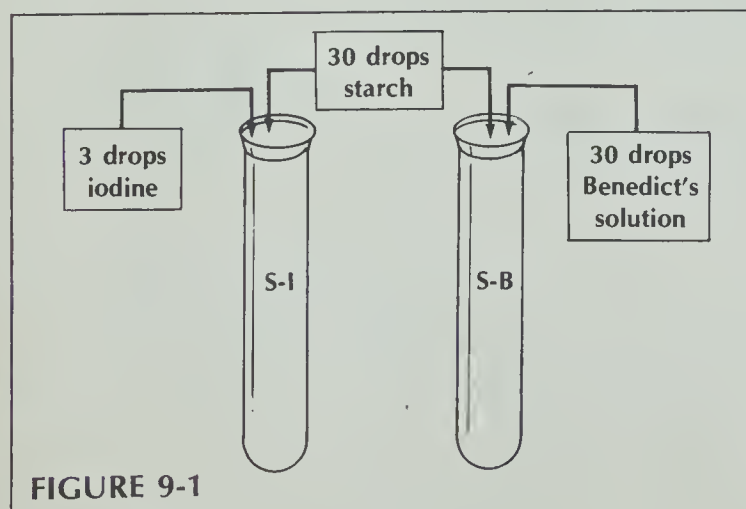


FIGURE 9-1

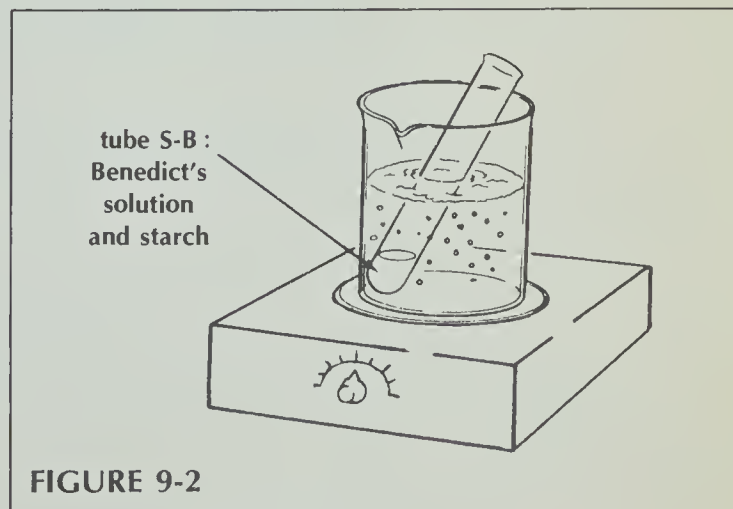


FIGURE 9-2

1. Is starch present in tube S-I? _____

2. Explain how you can tell. _____

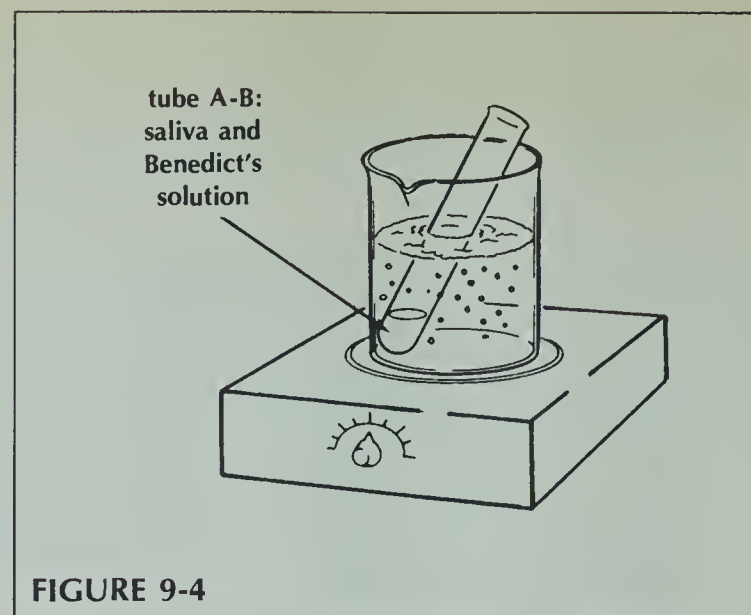
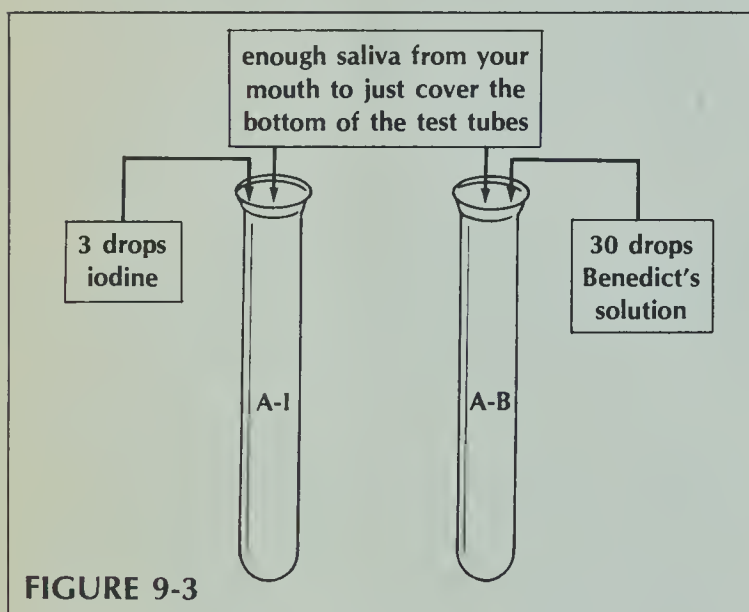
NOTE: When Benedict's solution is added to the tube, you should see a color. A bright blue color (original color of Benedict's) after heating tells you that glucose is not present. A change to green, yellow, orange, or red after heating tells you that glucose is present.

3. Is glucose present in tube S-B? _____

4. Explain how you can tell. _____

Part B. Testing the Properties of Salivary Amylase Enzyme

- Label two clean tubes as shown in Figure 9-3.
- Use Figure 9-3 as a guide to filling the test tubes.



- Heat *only* tube A-B in the hot water bath for 5 minutes (Figure 9-4).

- After heating tube A-B, record the color of the solutions in the two tubes. Use the middle column of Table 9-1.

5. Is starch present in your salivary amylase enzyme (saliva)? _____

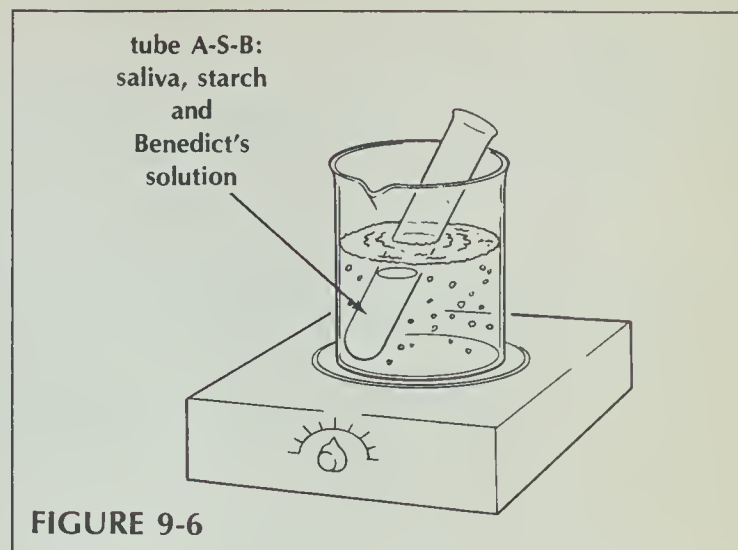
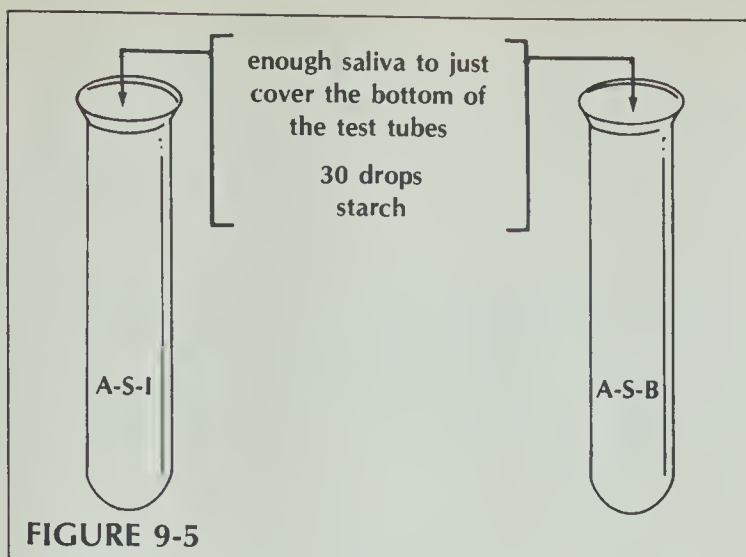
6. Is glucose present in your salivary amylase enzyme? _____

Part C. Testing the Properties of Starch Mixed with Salivary Amylase Enzyme

- Label two clean tubes as shown in Figure 9-5.
- Use Figure 9-5 as a guide to filling the test tubes.

TABLE 9-1. TESTING THE PROPERTIES OF AMYLASE

	STARCH ONLY	SALIVARY AMYLASE ONLY	STARCH AND SALIVARY AMYLASE MIXED
Iodine test color			
Benedict's test color			
Type of carbohydrate present (starch or glucose)			



• Mix the solutions in the tubes by gently swirling. Allow both tubes to stand for 5 minutes.

• *After* waiting, add two drops of iodine to the tube marked A-S-I.

• Add 30 drops of Benedict's solution to the tube marked A-S-B.

• Heat tube A-S-B in the hot water bath for 5 minutes (Figure 9-6).

• Record the color of the solutions in the two tubes. Use the last column of Table 9-1.

7. (a) Is starch still present in your tube filled with starch, salivary amylase, and iodine?

(b) Is there as much starch as was present in Part A? (HINT: If less starch is present, the

color will be light blue.) _____

8. Is glucose now present in your tube filled with starch, salivary amylase, and Benedict's solution? _____

• State in Table 9-1 the type of carbohydrate present in the mixed amylase and starch.

Analysis

1. In Part A, was starch changed into glucose? _____ What proof do you have? _____

2. In Part B, was salivary amylase changed into glucose? _____ What proof do you have? _____

3. (a) In Part C, was starch with salivary amylase changed into glucose? _____

(b) What proof do you have that this change occurred? _____

4. (a) Can starch alone change into glucose? _____

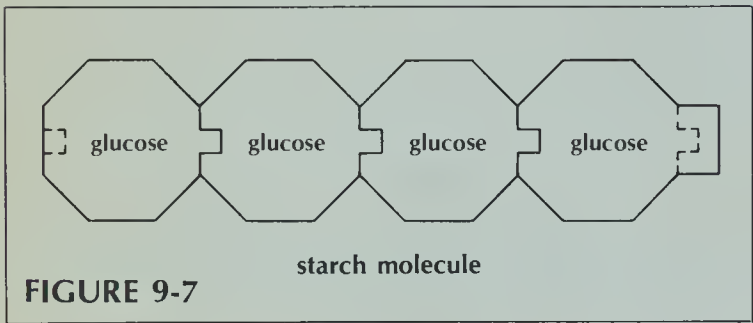
(b) What must be added to starch to change it to glucose? _____

(c) Where in your body does this change take place when you eat foods containing starch? _____

5. (a) A substance upon which an enzyme causes a change is called a substrate. What was the substrate in this experiment? _____
- (b) The substance which changes a substrate is called an enzyme. What was the enzyme in this experiment? _____

Extending Your Investigation

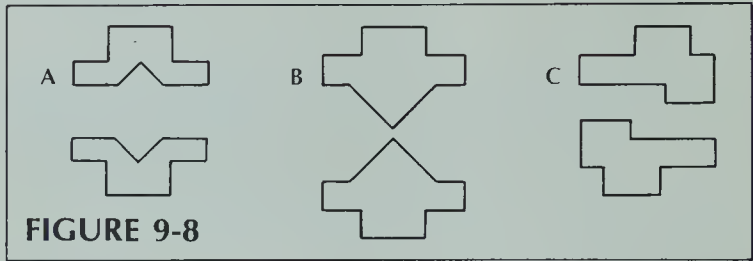
Figure 9-7 represents a starch molecule. Note that it is a long molecule made up of glucose molecules joined in a chain.



Salivary amylase changes starch into glucose by removing glucose molecules from the ends of the starch molecule. The best model to explain this action is that the enzyme “fits” exactly into the sites of attachment of the glucose molecules. This “weakens” the chemical bonds holding them together. As a result, the glucose molecule breaks from the starch molecule. Figure 9-8 represents different enzyme molecules. Which pair of shapes, A, B, or C, would best fit the starch molecule in Figure 9-7? _____

Which enzyme would best break down the starch? _____

After the end glucose molecule is removed, the enzyme moves to the next glucose molecule in the chain breaking it away. This continues down the chain. Eventually, all the glucose molecules are separated.



- Complete Table 9-2. Use the shapes in Figures 9-7 and 9-8 to draw the step-by-step sequence of changes. Follow the directions beside each space in Table 9-2.
1. How does the starch—amylase reaction (Table 9-2) resemble a lock and key (lock = starch; key = enzyme) model by which enzymes may carry on their functions? _____
2. A substrate is the molecule that an enzyme can change. Which molecule
- (a) was the substrate? _____
- (b) was the enzyme? _____

TABLE 9-2. MODEL OF STARCH AMYLASE REACTION	
Starch molecule (Figure 9-7)	Amylase molecule (Figure 9-8)
Starch molecule with amylase mole- cule fitting between points of glucose attachment	Glucose molecule freed from starch

CELL ENERGY

10

Energy within a cell exists in the form of chemical energy. A source of this chemical energy is a compound called adenosine triphosphate (ATP). ATP when changed to a compound called adenosine diphosphate (ADP) releases energy for biological work in a cell. ADP can be changed to ATP, but this reaction requires energy. During cell respiration, energy made available from the breakdown of glucose is used to change ADP to ATP.

In this investigation, you will

- use paper models to construct molecules of adenosine triphosphate (ATP) and adenosine diphosphate (ADP).
- determine similarities and differences between ATP and ADP.
- illustrate energy release when ATP is changed to ADP.
- study the ATP-ADP cycle.

Materials

tracing or typing paper
light cardboard (optional)

scissors
paste (optional)

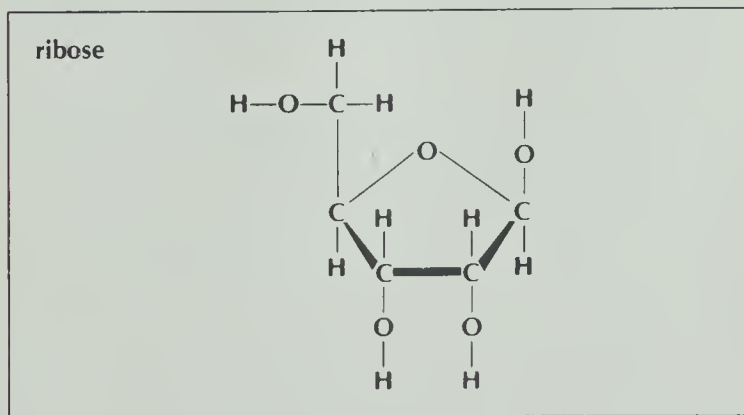
Procedure

Part A. The Chemical Structure of Adenosine Triphosphate

ATP is made up of smaller molecules or subunits—ribose, adenine, and phosphoric acid or phosphate groups.

Ribose Molecule

- Examine the structural formula of ribose.



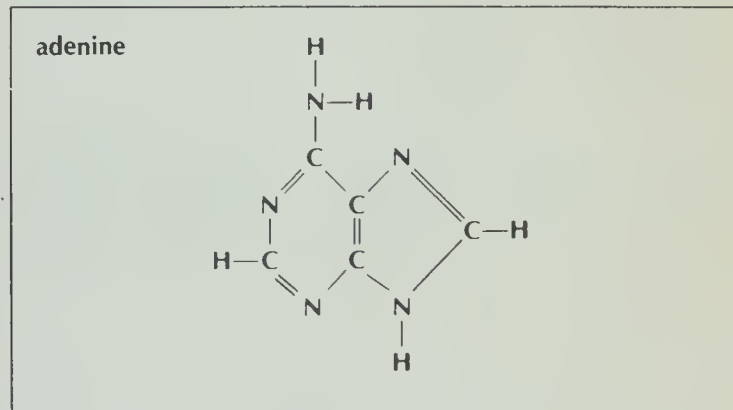
- What is the molecular formula of ribose? (Fill in the appropriate subscripts.) C___H___O___
- How does the number of hydrogen atoms compare to the number of oxygen atoms in ribose? _____

Ribose is a carbohydrate. It is different from glucose in one very important way. Glucose has six atoms of carbon in each molecule.

- How many carbon atoms are in ribose? _____

Adenine Molecule

- Examine the structural formula of adenine.



- What is the molecular formula of adenine? (Fill in the appropriate subscripts.) C___H___N___
- (a) What element is in adenine that is not in carbohydrates? _____
(b) What element is in carbohydrates that is not in adenine? _____

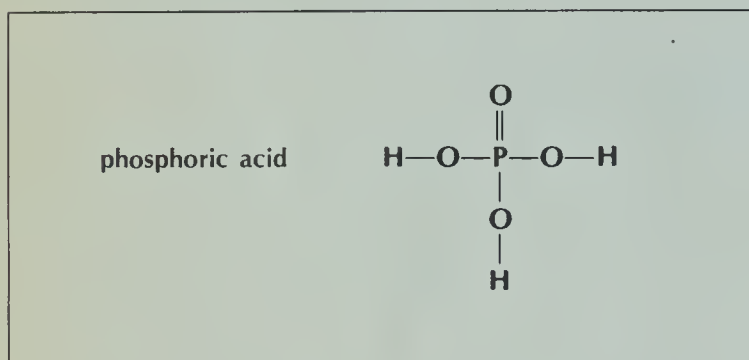
(c) What name is used to describe the H-N-H group? _____

(d) Is adenine an amino acid? _____

Phosphoric Acid

● Examine the structural formula of phosphoric acid. Phosphoric acid is much like the phosphate groups in ATP.

NOTE: The letter P represents the element phosphorus.



6. What is the molecular formula of phosphoric acid? (Fill in the appropriate subscripts.)

H__ P__ O__

Constructing an ATP Molecule

An ATP (adenosine triphosphate) molecule is made up of one ribose molecule, one adenine molecule, and three phosphate groups joined.

7. What does the prefix tri- in triphosphate mean? _____

8. Adenosine is a word made up of a combination of letters from two different words. Part of the word comes from ribose (the letters "os"). Where do the letters "aden" and "ine" come from? _____

● Trace the models in Figure 10-1 onto a separate piece of paper.

● Cut out the models of adenine, ribose, and phosphoric acid you just traced. **CAUTION:** *Always be careful with scissors.* You may want to paste the page on lightweight cardboard before cutting out the models. *Cut along solid lines only.*

● Attempt to join the adenine and ribose molecules much as you would pieces of a puzzle.

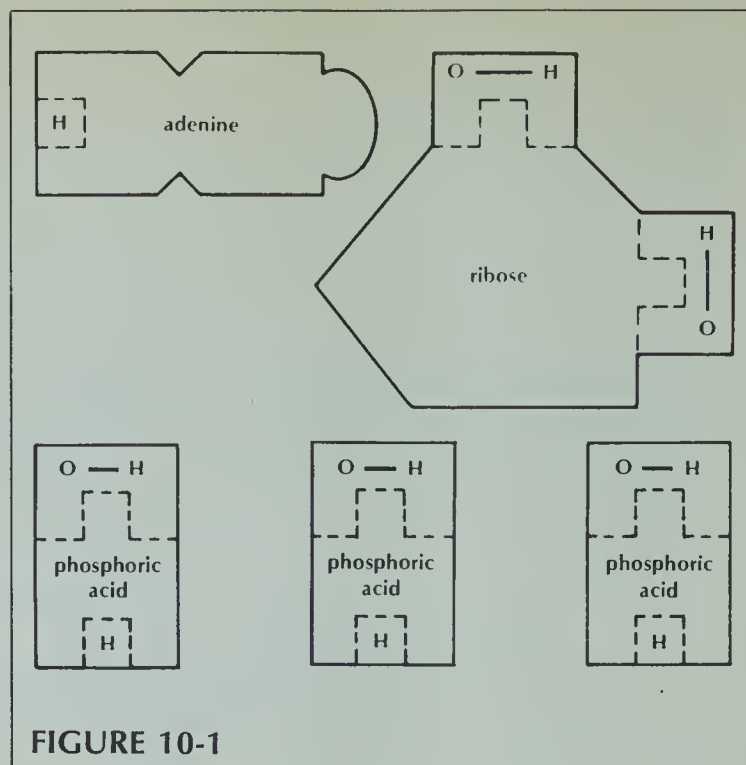


FIGURE 10-1

9. What end parts must first be removed from each molecule in order for adenine and ribose to fit together? _____

● Remove these parts. The adenine and ribose molecules can now be chemically joined. New points of attachment or chemical bonds are formed.

10. What molecule is formed from the parts that are removed? _____

● Examine the phosphoric acid models.

● Attach one of the three phosphates to the ribose molecule by removing an H from the phosphoric acid molecule.

● Attach the remaining phosphoric acid molecules one at a time to the phosphate group already attached to ribose.

11. What did you remove to make these connections? _____

You have now built an ATP molecule.

12. List the five "building blocks" that are needed to form one ATP molecule. _____

13. What is required for the chemical combination of these parts? (HINT: See introduction.) _____

Part B. Gaining Energy from ATP as It Changes to ADP

- Remove one phosphate group from the end of your ATP model.

14. How many phosphate groups are still attached to the original molecule? _____

15. This new compound with one fewer phosphate groups than before is called adenosine diphosphate (ADP). What does the prefix di-

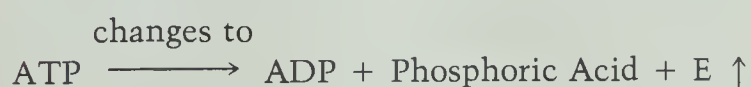
mean? _____

16. List the four "building blocks" that are needed to form one ADP molecule. _____

17. Explain how an ATP molecule is changed to an ADP molecule. _____

18. What is released when ATP is changed to ADP? (HINT: See introduction.) _____

So far we have seen that ATP can be changed to ADP with energy given off. This change can be written using a type of shorthand. For example, this change may be written as follows:



19. What might the letter E in the above equation be an abbreviation for? _____

Part C. Changing ADP to ATP

ATP can be formed within living organisms if the correct raw materials are available. These raw materials are ADP, phosphoric acid, and energy. We can again use models to help show how ATP is formed.

- Construct an ADP molecule.
- Attach a phosphoric acid molecule to the ADP model. If necessary, remove any H or OH ends to provide the point of attachment. This combination forms an ATP molecule.

Energy is needed to change ADP back to ATP. Using a type of shorthand, this change can be written as follows:



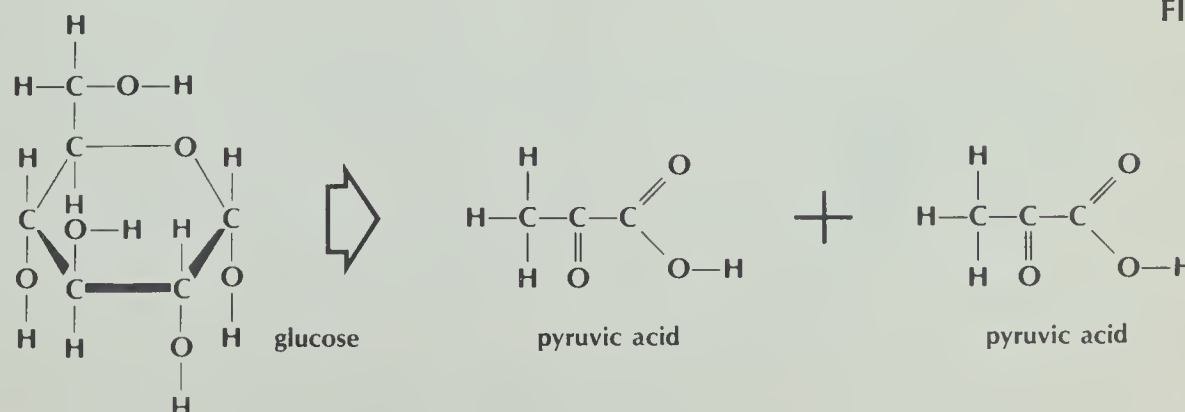
20. What might the letter E in the above equation be an abbreviation for? _____

Part D. An Energy Source for Converting ADP to ATP

From where does the energy to form ATP from ADP come? It does not come from the energy released when ATP changes to ADP. The energy comes from a different source. Energy is "stored" in all compounds. Food such as glucose contains much energy. Glucose is the major source of energy for ATP formation. Energy is released from food during cellular respiration.

- Examine the structural formula for glucose shown in Figure 10-2. In respiration, glucose is broken down into two identical molecules of a chemical called pyruvic acid. This step is called glycolysis ("glyco-" = glucose, "-lysis" = break apart). Glycolysis is the first step in cellular respiration (Figure 10-2).

FIGURE 10-2



The lines which connect one atom to another represent chemical bonds. (A double line like this // represents two bonds.)

21. Count and record the number of bonds in

(a) one molecule of glucose. _____

(b) two molecules of pyruvic acid. _____

NOTE: Be sure to count double lines as two bonds.

22. Is the amount of energy in one glucose molecule the same as the energy in both

pyruvic acid molecules? _____

23. How is some of this extra energy used? _____

Pyruvic acid is broken down further to yield more energy. Energy released from glucose during respiration is used in building more molecules of ATP.

Analysis

1. List the name and number of each molecule forming ATP. _____

2. List the name and number of each molecule forming ADP. _____

3. How do ADP and ATP differ in

(a) number of phosphate groups? _____

(b) number of ribose molecules? _____

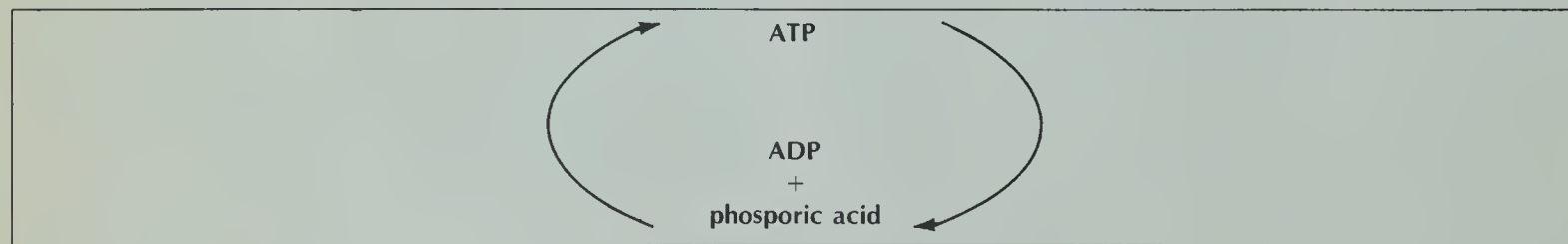
(c) number of adenine molecules? _____

(d) amount of potential chemical energy? _____

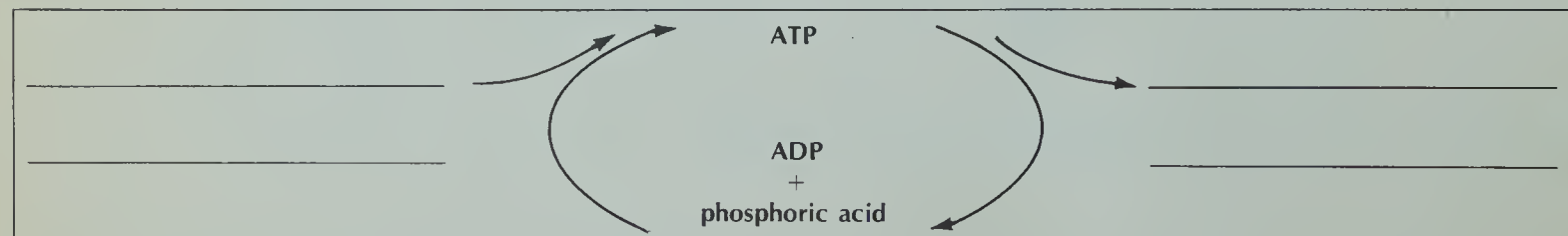
4. Your muscles require energy to move your body. What chemical directly supplies your muscles with energy? _____

5. What process directly supplies your body with the energy it needs to change ADP back to ATP? _____

6. Changes from ATP to ADP and back again are often said to occur in a cycle. One change follows the other in this manner:



Energy is both given off and used for work. Energy is also supplied during cellular respiration. Complete the diagram below by writing in the words "energy given off" and "energy supplied from respiration" in the correct spaces.



FACTORS INFLUENCING RATE OF YEAST RESPIRATION

11

All living systems respire. During respiration, food, usually in the form of glucose, is "burned." One of the products of respiration is carbon dioxide. The amount of carbon dioxide released during respiration indicates the respiration rate.

In this investigation, you will

- (a) count and record bubbles of carbon dioxide gas given off by respiring yeast cells.
- (b) compare respiration rates at two different temperatures.
- (c) compare respiration rates when using different foods for the yeast cells.

Materials

yeast cake
droppers—4
test tubes—4
one-hole stoppers to fit test tubes—4
20% glucose solution
cold water
clay (optional)
ice
straight pins—4
tape
warm water
thermometer (Celsius scale)
glass marking pencil (wax)
quart milk cartons with tops cut off—2
yeast food A
yeast food B
yeast food C
yeast food D
cloth towel
graduated cylinder

Procedure

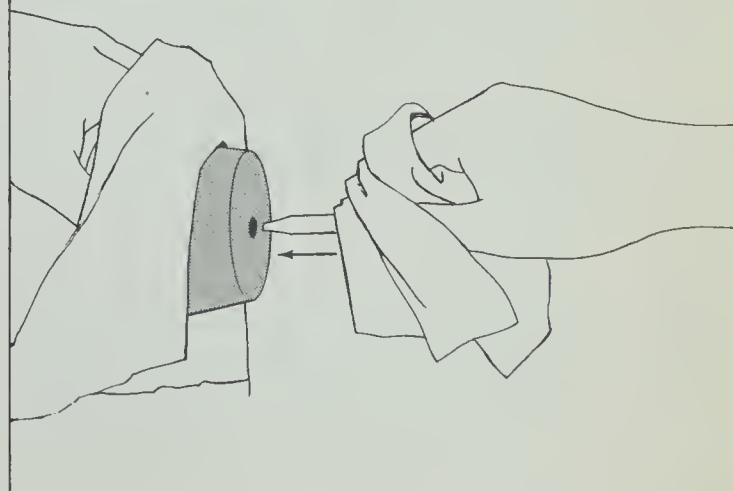
Part A. Influence of Temperature on Yeast Respiration Rate

NOTE: Work in pairs.

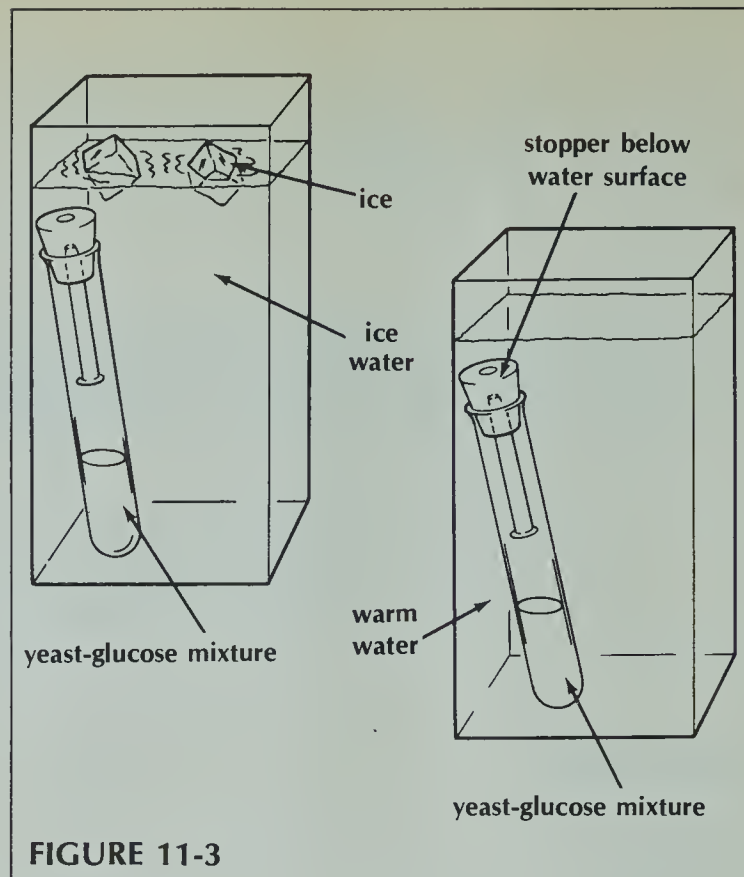
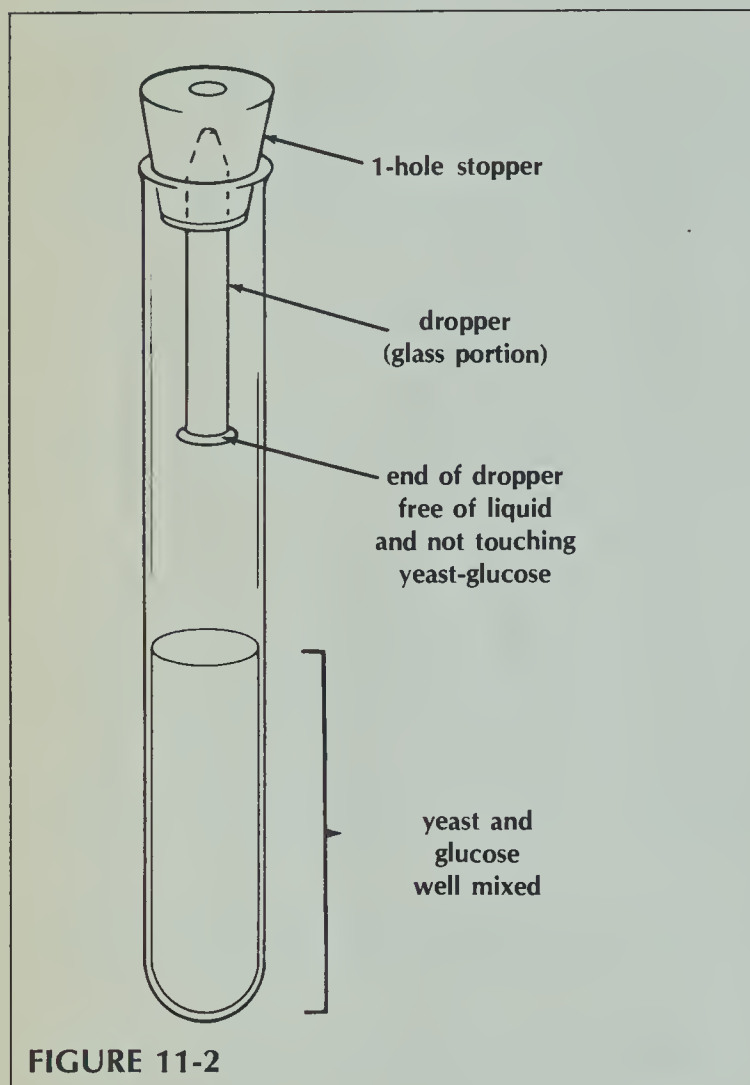
- Remove the rubber bulbs from two droppers.
- Wet the glass portion of each dropper. Push the small ends of the droppers into the small ends of two one-hole stoppers (Figure 11-1).
CAUTION: Be careful not to break the glass. A gentle twisting motion works best. Wrap your hands in a cloth towel while inserting the droppers into the stoppers.

- To each of two test tubes, add a 1-cm cube of yeast and 12 mL of 20% glucose solution.

FIGURE 11-1



- Mix the contents of each test tube making sure that the yeast cube has dissolved.
- Add a stopper with a dropper to each of the test tubes (Figure 11-2). Make sure all seals are tight.
- Be sure that the ends of the droppers are not in the liquids. If necessary, pour enough liquid from the test tubes to keep the dropper above the liquid (see Figure 11-2).



- Measure the temperature of the water in each carton and record it in Table 11-1.
- Allow the tubes to sit undisturbed for two minutes. Then count the number of bubbles that rise from the opening of each stopper per minute for 10 minutes. Each team member should be responsible for counting the bubbles that rise from one test tube.
- Record the number of bubbles in the first two columns of Table 11-1.

Part B. Influence of Different Foods on Yeast Respiration Rates

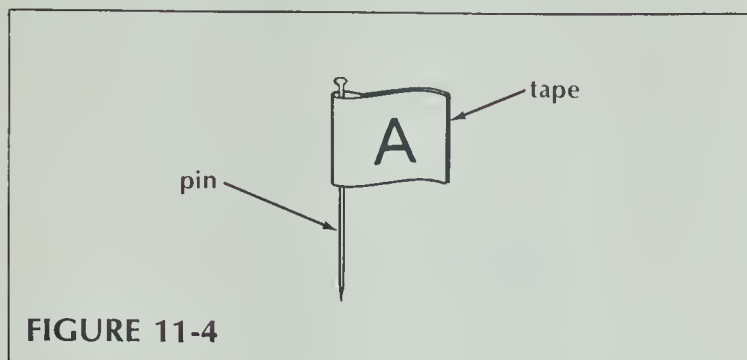
STOP: Check to make sure that your test tubes resemble Figure 11-2 before going on to the next part of the investigation.

- Place one test tube into a milk carton almost filled with water and ice (or very cold water).
- Place the other test tube in a milk carton almost filled with warm water. Adjust the temperature of the water to 37 or 38°C by adding hot or cold water as needed (Figure 11-3).

NOTE: The stoppers must be below the water surface in the milk cartons. Use Figure 11-3 as a guide. If test tubes float or tip over, add a small plug of clay to the outside bottom of each test tube.

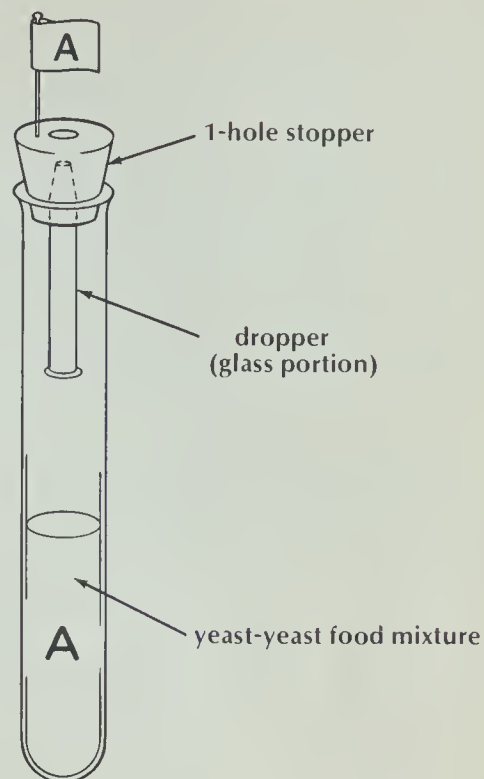
- Prepare four stoppers and four test tubes as in Part A. Place a yeast cube into each tube. Add 12 mL of "Food A" into one tube. Label this tube "A." Mix the yeast and food.
- Place 12 mL of "Food B" into the second tube, 12 mL of "Food C" into the third tube, and 12 mL of "Food D" into the fourth tube. Label the tubes. Mix all tubes so that the yeast dissolves.
- Prepare four pin markers as follows. Wrap a piece of tape around a pin (Figure 11-4). Label this marker "A." Prepare three more markers, labeling them "B," "C," and "D." These markers will help you identify which tube (or tubes) are giving off carbon dioxide bubbles.

- Add a stopper with a dropper to each of the four tubes. Insert the pin markers into the stoppers of the proper tubes (Figure 11-5).



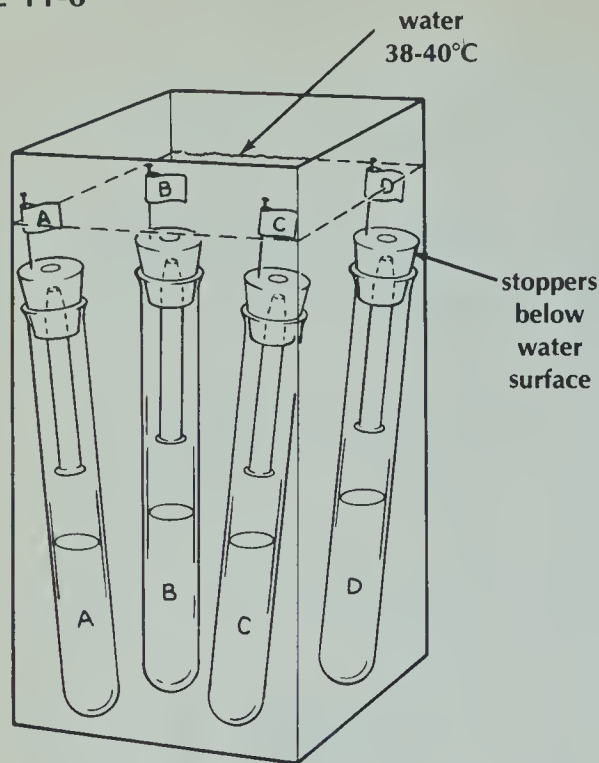
STOP: Check to make sure that
 (a) yeast and food are well mixed.
 (b) the end of the dropper closest to yeast-food mixture is free of liquid.

- Place all four tubes into a milk carton filled almost to the top with water adjusted to between 38 and 40°C (Figure 11-6).

FIGURE 11-5**TABLE 11-1. YEAST RESPIRATION RATES**

NUMBER OF BUBBLES PER MINUTE						
TIME IN MINUTES	WARM TEMPERATURE _____°C	COLD TEMPERATURE _____°C	Food A	Food B	Food C	Food D
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

FIGURE 11-6



- Again make sure that the stoppers are below the water surface. Use Figure 11-6 as a guide.

- Allow the test tubes to sit undisturbed for two minutes. Then count the number of bubbles per minute that rise from each test tube for 10 minutes. Each team member should be responsible for counting the bubbles from two test tubes.

- Record the number of bubbles in Table 11-1.

Part C. Comparing Class and Individual Data

- Complete Table 11-2 by recording the total number of bubbles recorded by your team for Parts A and B.

- Totals for each team should then be posted on the chalkboard and class averages determined. Record class averages for Parts A and B in Table 11-2.

TABLE 11-2. TOTAL BUBBLES FOR 10 MINUTES

	YOUR DATA	CLASS AVERAGE
Cold water		
Warm water		
Food A		
Food B		
Food C		
Food D		

Analysis

1. Write a paragraph to summarize Part A of this investigation. Include (a) the purpose of Part A, (b) how respiration rate was measured, (c) the type of living organism used in this investigation, (d) how different temperatures of water influenced the respiration rate of your yeast (use specific data from your results to help support your statements), (e) an explanation for why respiration rates may differ with different temperatures, (f) an explanation of how class averages compare in general to your individual team's data, and (g) several reasons your data and class averages may not agree exactly.
2. Write a paragraph to summarize Part B of this investigation. Include all of the points listed above. However, remember that you are comparing the influence of different foods supplied to your yeasts on respiration rate.

THE BASIC UNIT OF LIFE

12

When different types of cells are viewed under a microscope, different cell parts can be seen. Certain living cells are best for showing parts like a nucleus or cell membrane. Once living (preserved) cells are best for showing parts like a cell wall. Cells from producer organisms (plants) will show parts such as chloroplasts and cell walls. Most consumer organism cells do not have these parts, although fungi have cell walls. We will not consider fungi in this investigation.

In this investigation, you will

- observe a variety of living and once living materials under the microscope.
- determine if these materials do or do not show a cellular type of organization.
- study and locate under the microscope six specific cell parts—cell wall, cell membrane, cytoplasm, nucleus, nucleolus and chloroplasts.
- compare the cell parts found in plant and animal cells.

Materials

microscope
microscope slides
coverslips
water
cork
razor blade (single-edge)
iodine stain
toothpicks
dropper
saxophone reed
methylene blue stain
onion bulb
Elodea (water plant)
frog blood, prepared slide

Procedure

Part A. The Cell Wall

Cork cells are excellent for studying a cell part common to all plant cells. This part is the cell wall. In a cork cell, the cell wall is easily visible. The cork is no longer living. The cell wall remains as the only evidence of once living materials.

- Use a razor blade to slice off a very thin section of cork using Figure 12-1 as a guide. Note that the slice should be made from the side of the cork, not its top or bottom. The slice must be tissue paper thin. Shavings of cork are ideal size. **CAUTION:** *Slice away from your fingers, not toward them, to avoid cuts.*

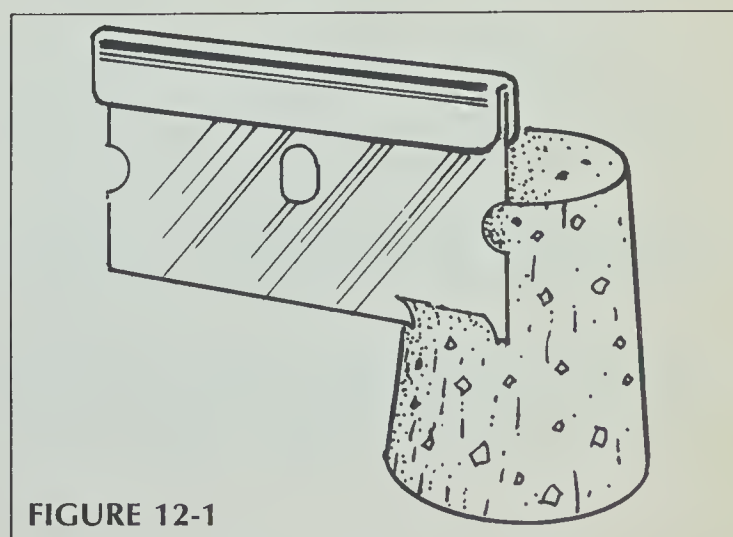
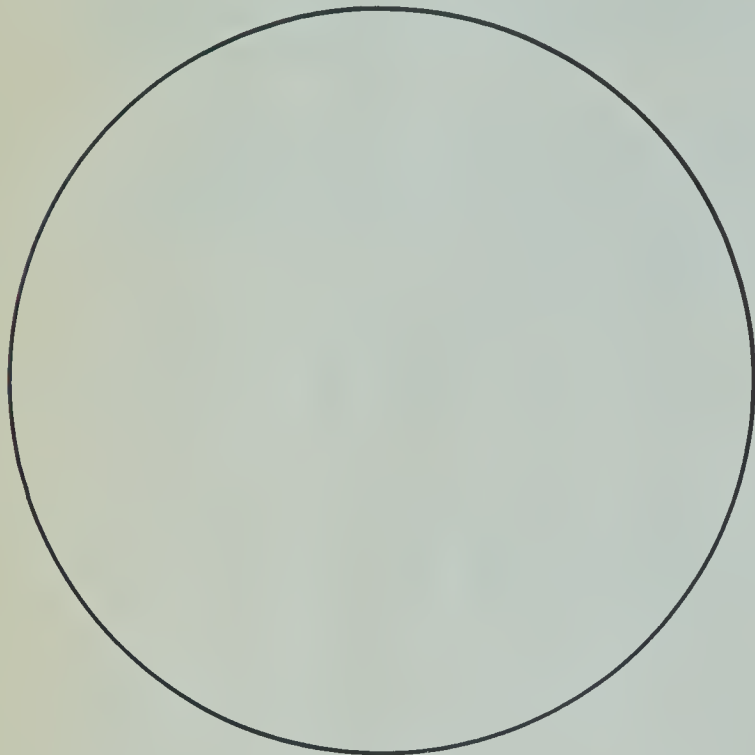


FIGURE 12-1

- Prepare a wet mount of your cork slice.
- Examine the cork under low power and then high power of your microscope. Use the fine adjustment to obtain a three-dimensional view of the cells.
- Use the space below to draw several cork cells as they appear under high magnification. Label *cell wall*.



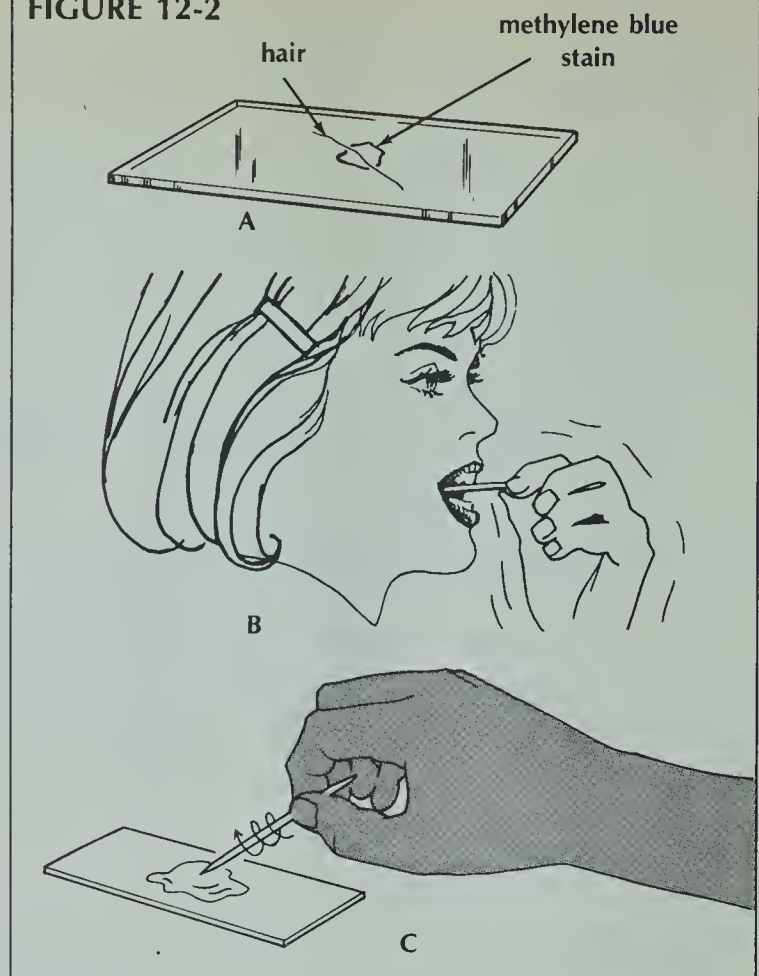
cork cells

Part B. Cell Membrane and Cytoplasm

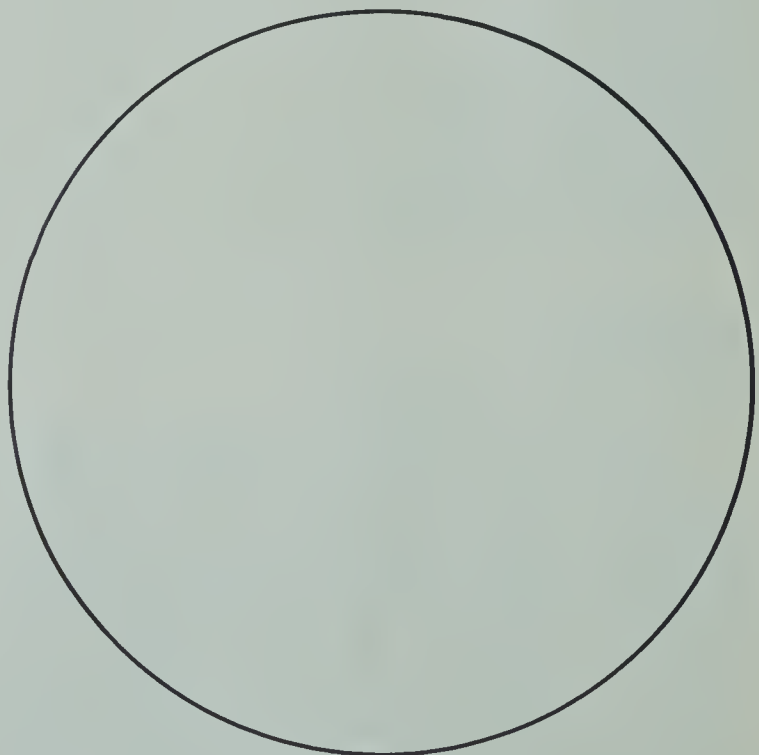
Human cheek cells may be used for viewing the cell membrane and cytoplasm. A cell membrane is a thin outer boundary which surrounds the cell and separates it from neighboring cells. Cytoplasm is the jellylike inner portion of the cell.

- Place a drop of methylene blue stain and a strand of hair onto a slide. Use Figure 12-2A as a guide.
- *Gently* scrape the *inside* of your cheek with the end of a toothpick. You will not be able to see anything on the toothpick when you remove it from your mouth (Figure 12-2B).
- Dip the toothpick into the stain on the slide and mix once or twice (Figure 12-2C).
- Add a coverslip and examine under low and high power of your microscope. (Use the hair as an aid in locating the proper depth for the cells.)

FIGURE 12-2



- Locate and examine cells that are separated from one another rather than those that are in clumps.
- Use the space below to draw several cheek cells as they appear under high magnification. Label the *cell membrane* and *cytoplasm*.



cheek cells

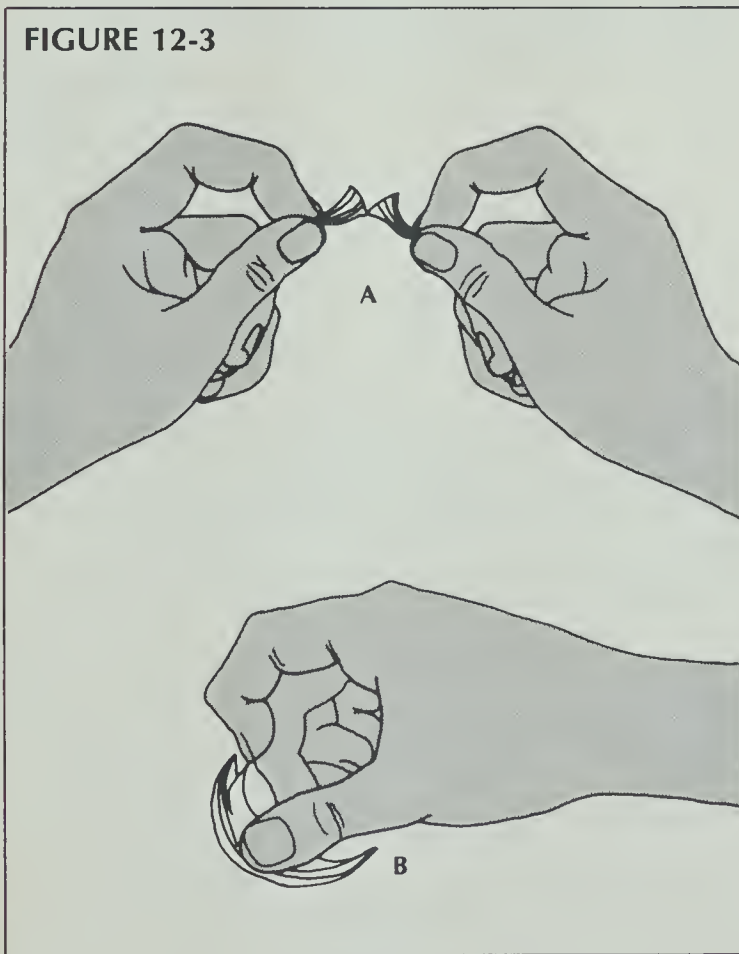
Part C. Cell Nucleus and Nucleolus

Onion cells may be used to show a cell's nucleus and nucleolus. These two structures appear within most living cells. There may be several nucleoli (plural of nucleolus) appearing as tiny dots within each cell's nucleus. The nucleus will appear as a round structure inside each cell.

Follow these steps in preparing onion cells for your wet mount:

- Snap an onion bulb scale (part of the onion you eat) in half (Figure 12-3A).
- Use your fingernail to peel off a thin layer of onion tissue (Figure 12-3B).
- Place one thin onion layer onto a microscope slide.
- Uncurl or unfold any overlapped portion of the cell layer. Make sure the layer is perfectly flat. Add a drop or two of iodine stain to the onion. **CAUTION:** *If iodine spillage occurs, rinse with water and call your teacher immediately.* Add a coverslip to the stained onion. Tap the coverslip gently with the eraser end of a pencil to drive out any air bubbles.

FIGURE 12-3



- Observe the cells under both low and high power of your microscope. Note the brick wall appearance of the cells with cell walls separating the cells.

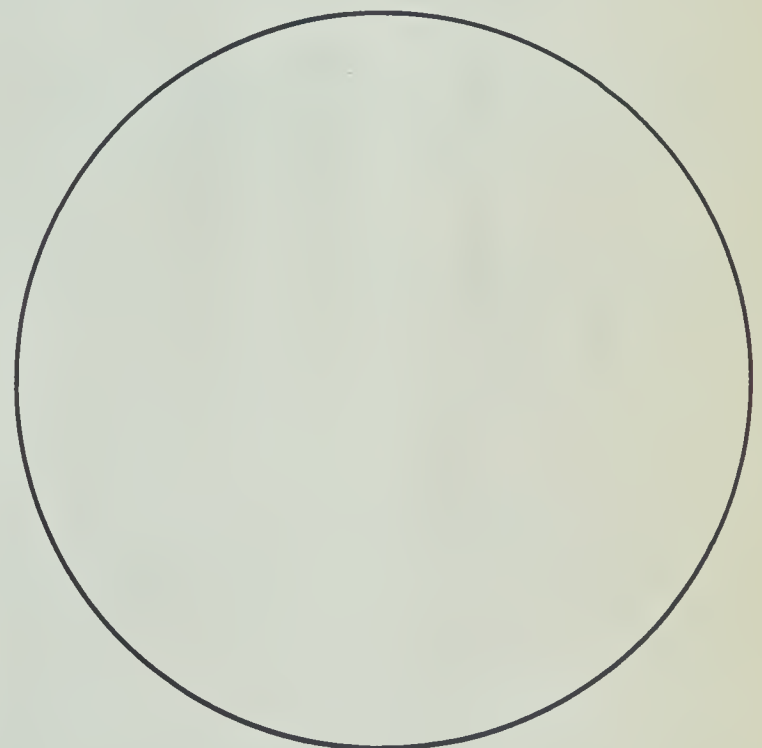
- Locate a small round structure, the nucleus, within each cell. Examine a nucleus carefully by focusing up and down through the cell.

- With high power, observe the tiny dots or eyelike structures within the nucleus. These are nucleoli.

The outer edge of the nucleus is made up of a thin covering called the nuclear membrane.

- Diagram a single onion cell in the space provided as it appears under high power.

- Label the *cell wall*, *nucleus*, *nucleolus*, and *nuclear membrane*.

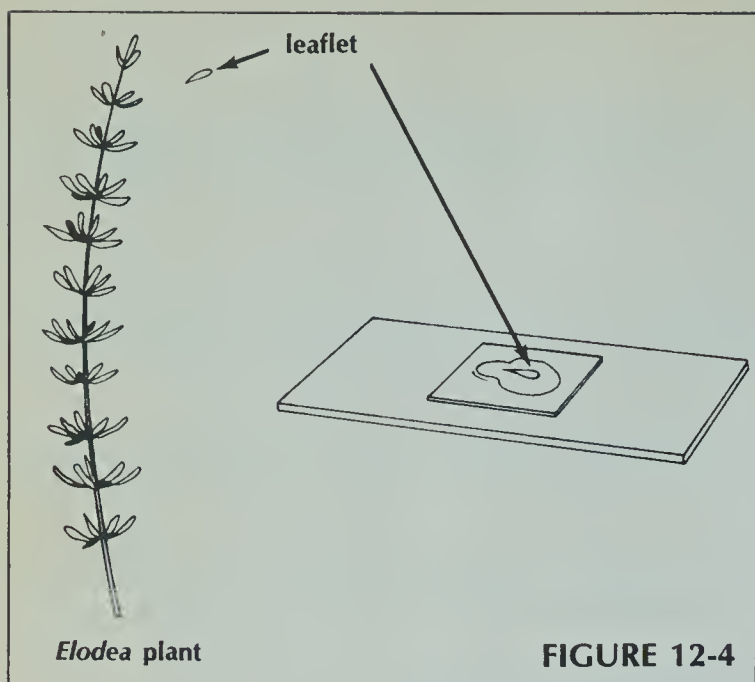


onion cell

Part D. Chloroplasts

Another cell part found in the cells of many producers is the green chloroplast. *Elodea*, a common water plant, shows these important structures well.

- Prepare a wet mount of an *Elodea* leaflet. Use Figure 12-4 as a guide.

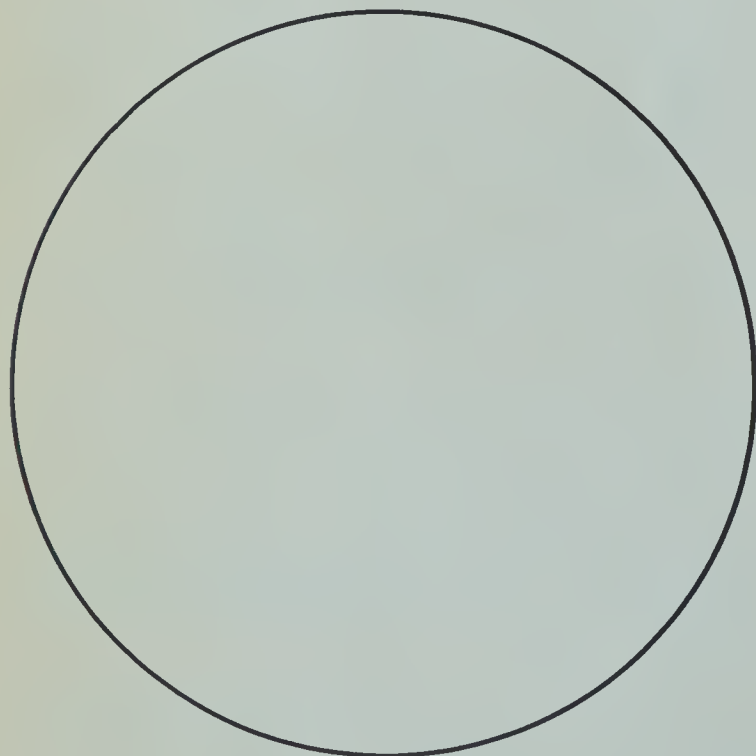


- Using low power of your microscope, position your slide so you are looking near the edge of the leaflet. Locate green, oblong cells. Examine these cells under high power.

- Note the small green organelles inside each cell. These are chloroplasts. Movement of the chloroplasts within the cell often can be observed. Attempt to locate moving chloroplasts.

- Diagram a single *Elodea* cell in the space provided. Use high power.

- Label *cell wall* and *chloroplast*.



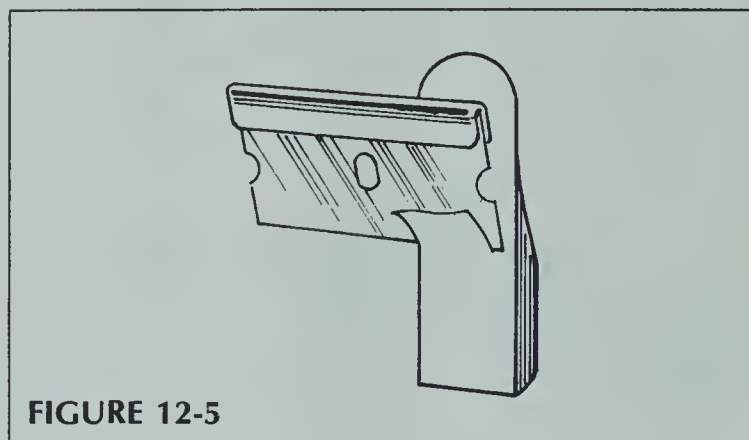
Elodea cell

Part E. Plant or Animal Cell?

Bamboo Stem

- Prepare a wet mount of bamboo stem cells by using the following steps:

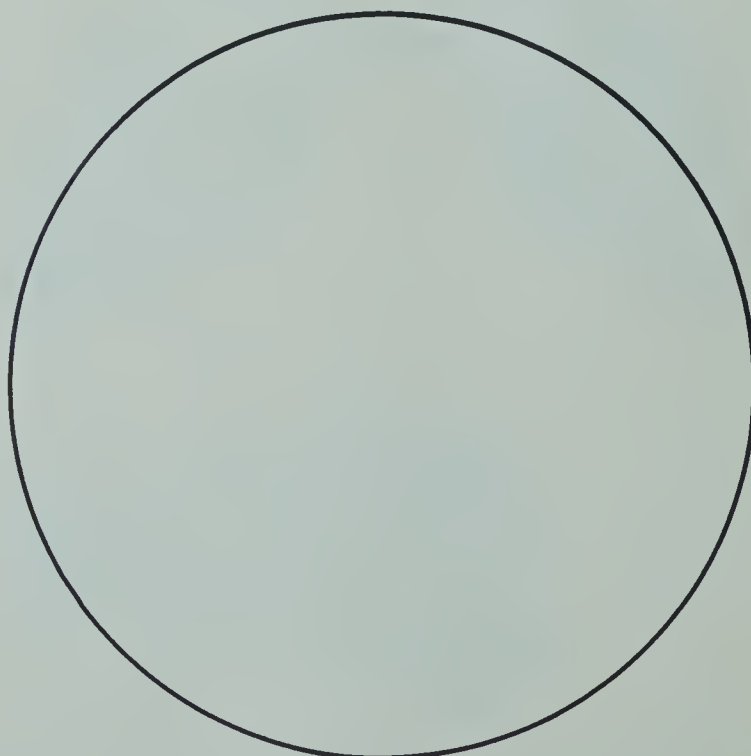
- (a) Hold a razor blade against the flat side of a reed (Figure 12-5).
- (b) Carefully cut away from your fingers and remove as thin a slice as possible from the reed.
- (c) Place this thin slice on a slide in a drop of water. Add a coverslip.



- Observe the bamboo stem under low power.

- Diagram several bamboo cells in the space provided.

- Label the *cell wall*, *cytoplasm*, and *nucleus* only if these parts are present.



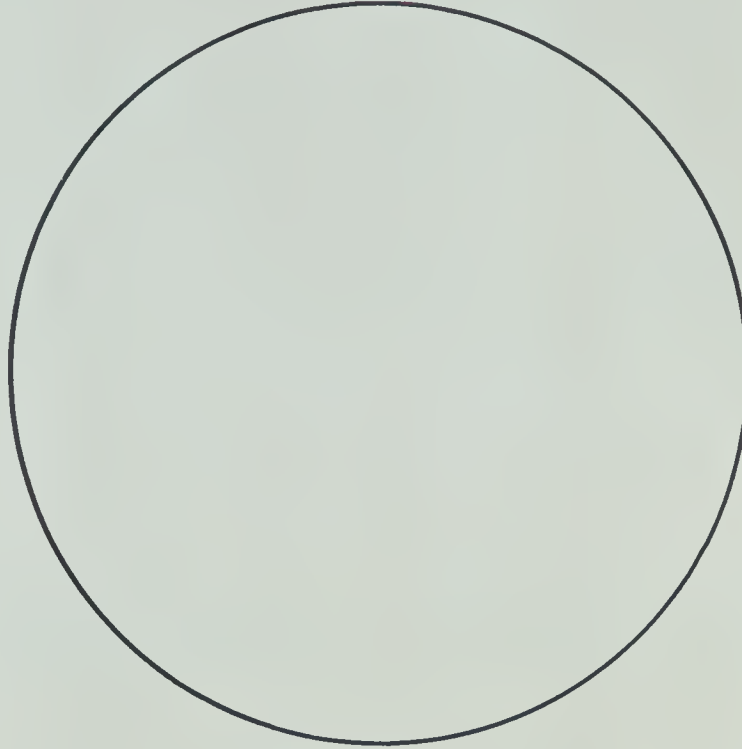
bamboo cells

Frog Blood

● Observe a prepared slide of frog blood. Use low and high power. The colors you see are not natural. Stains have been added to these cells to make viewing easier.

● Diagram several frog blood cells in the space provided. Use high power.

● Label the *cell wall*, *cell membrane*, *cytoplasm*, and *nucleus* only if these parts are present.



frog blood cells

Analysis**Analysis, Part A:**

1. Is the cork you used alive? _____
2. What are the small units that can be seen under high power called? _____
3. Do these units appear filled or empty? _____
4. What specific cell part is all that remains of the cell? _____
5. In 1665, Robert Hooke, an English scientist, reported an interesting observation while looking through his microscope at cork. "I took a good clear piece of cork, and with a penknife sharpened as keen as a razor, I cut a piece of it off, then examining it with a microscope, me thought I could perceive it to appear a little porous, much like a honeycomb, but that the pores were not regular."
 - (a) What were the honeycomb units at which Hooke was looking? _____
 - (b) What specific cell part was all that was left of the cork? _____
6. (a) Is cork produced by a plant or an animal? _____
 - (b) Do animal cells have cell walls? (NOTE: See introduction.) _____
7. Use your text to determine the name of the chemical which makes up the cell wall. _____

Analysis, Part B:

1. Describe the shape of a cheek cell. _____
2. (a) Are cheek cells produced by plants or animals? _____
(b) Is a cell wall present? _____
3. Are cheek cells alive? _____
4. Describe the location of the cell membrane. _____
5. Use your text to determine the function of the cell membrane. _____

6. (a) Describe the location of the cell's cytoplasm. _____
(b) Describe the appearance of cytoplasm. _____
7. Use your text to determine the function of a cell's cytoplasm. _____

8. Why was a stain added to the cheek cells? _____
9. Do you have evidence that living things (or once living things) are composed of basic units called cells?
_____ Explain. _____

Analysis, Part C:

1. Describe the shape of an onion cell. _____
2. (a) Are onion cells produced by plants or animals? _____
(b) Is a cell wall present? _____
3. (a) Describe the shape of the nucleus of an onion cell. _____
(b) Within what cell part already studied does the nucleus lie? _____
4. What is the function of a cell's nucleus? (Consult text if necessary.) _____
5. (a) Describe the shape of the nucleolus of an onion cell. _____
(b) Where is the nucleolus found? _____
6. What is the function of a cell's nucleolus? (Consult your text if necessary.) _____

7. What structure separates the contents of the nucleus from the cytoplasm? _____
8. Why were the cells stained? _____

Analysis, Part D:

1. Describe the shape of an *Elodea* cell. _____

2. (a) Is elodea a plant or animal? _____
 (b) Is a cell wall present? _____
3. Describe the _____
 (a) color of the chloroplasts. _____
 (b) shape of the chloroplasts. _____
4. Within what cell part already studied do chloroplasts lie? _____
5. Use your text to determine the function of chloroplasts. _____
6. Are chloroplasts usually present in consumer cells? _____ Explain. _____

Analysis, Part E:

1. Describe the shape of bamboo cells. _____
2. (a) Can a cell wall be seen in bamboo? _____
 (b) Is bamboo a plant or animal? _____ Explain. _____

3. Describe the shape of frog blood cells. _____
4. (a) Can a cell wall be seen in frog blood cells? _____
 (b) Are blood cells from a producer or consumer? _____ Explain. _____

5. (a) What cell part name is used to describe the outer edge of a frog blood cell? _____

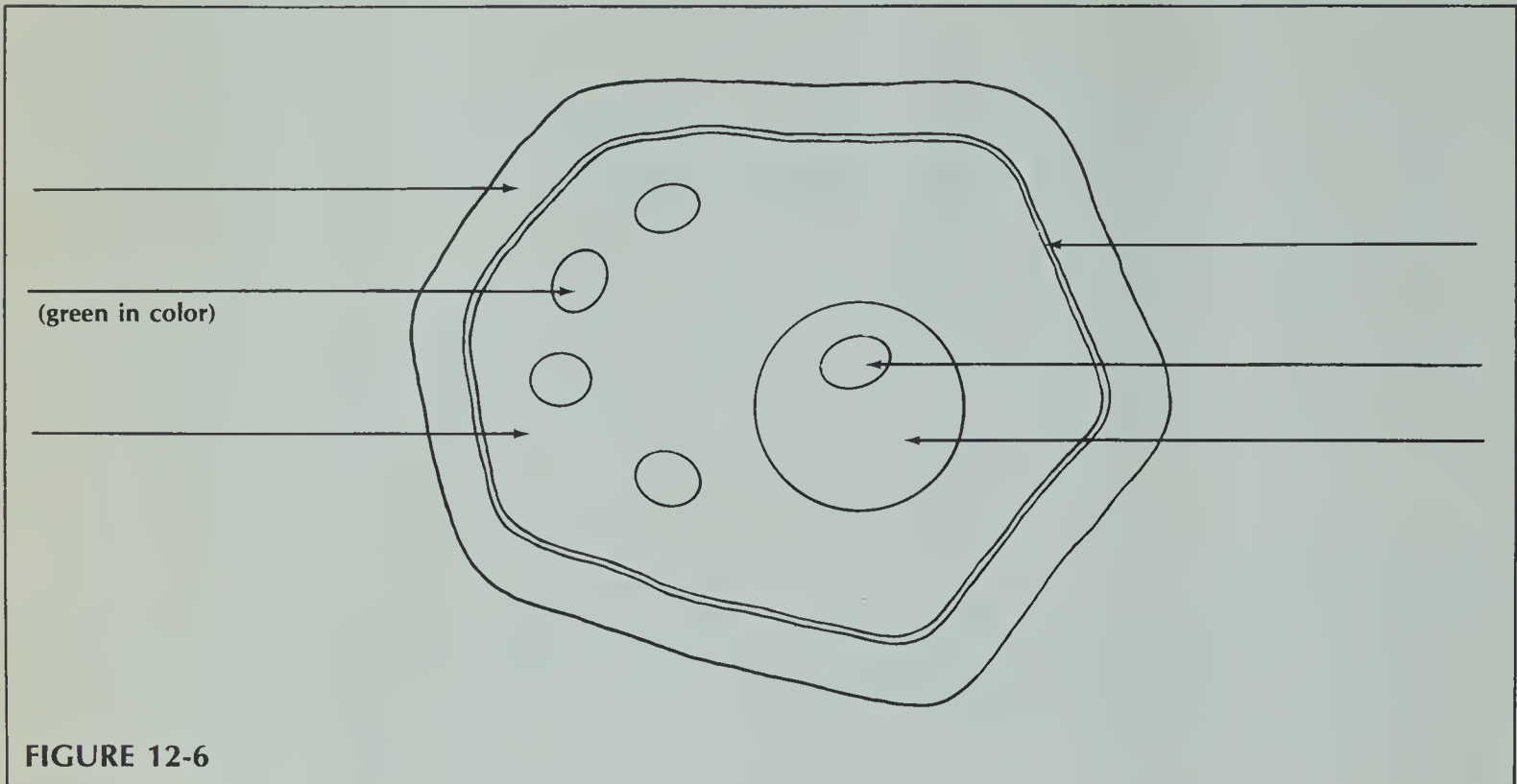
- (b) What cell part name is used to describe the dark center of a frog blood cell? _____

Analysis, General:

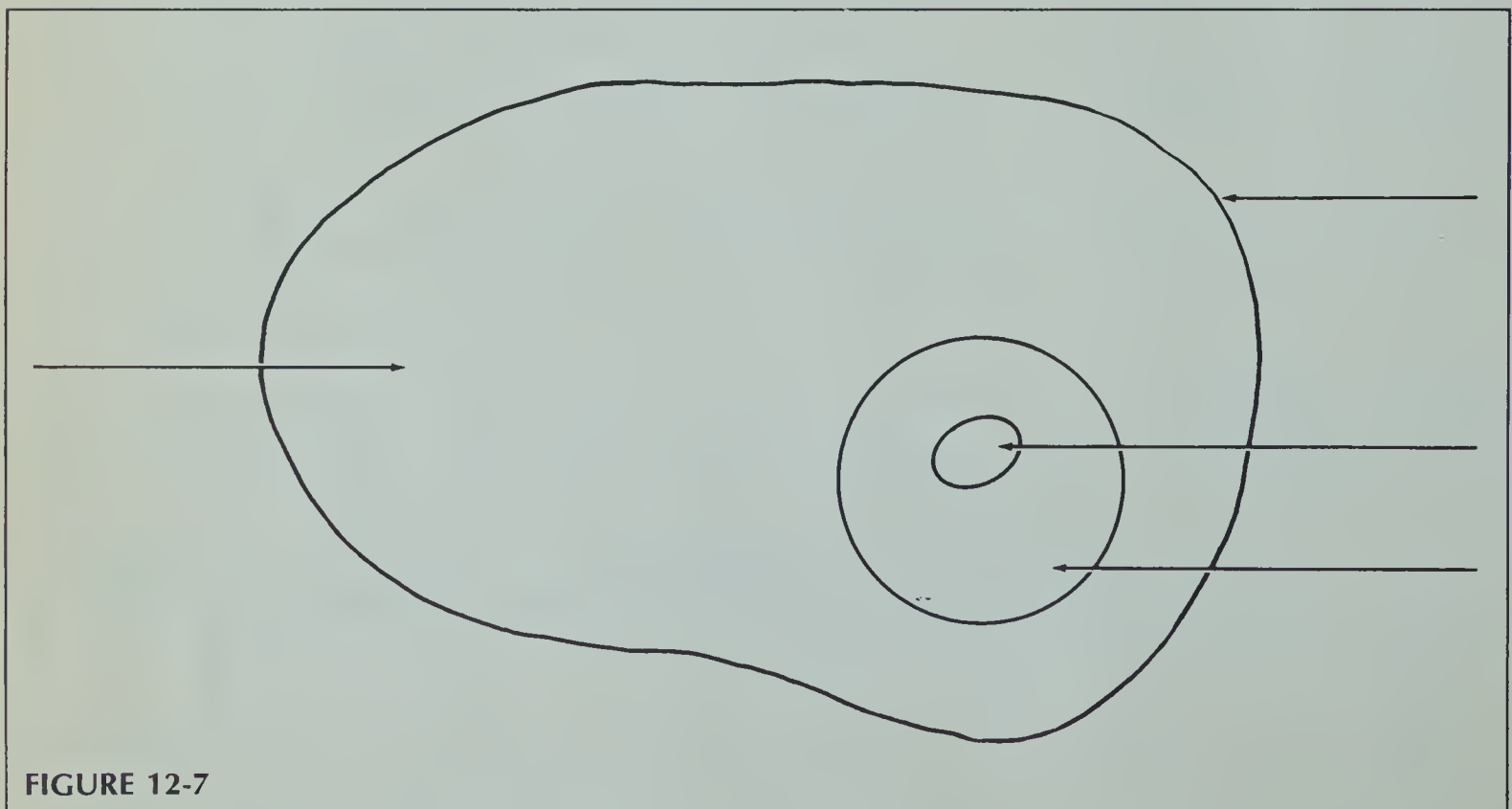
1. Complete this chart. Indicate by using check marks each structure contained in a plant or animal cell.

	NUCLEUS	CELL WALL	CYTOPLASM	NUCLEAR MEMBRANE	NUCLEOLUS	CHLOROPLASTS	CELL MEMBRANE
Animal Cell							
Plant Cell							

2. Complete Figure 12-6 of a "typical plant cell." Use your text to determine where the following plant cell parts are located: *vacuoles*, *mitochondria*, *Golgi bodies*, *endoplasmic reticulum*, *ribosomes*, and *lysosomes*. Draw these parts as they would appear under an electron microscope onto Figure 12-6 and correctly label them. Label these parts which are already drawn for you: *cell wall*, *cytoplasm*, *cell membrane*, *chloroplast*, *nucleus*, *nucleolus*.



3. Complete Figure 12-7 of a "typical" animal cell. Label these parts which are already drawn for you: *cell membrane*, *nucleus*, *nucleolus*, *cytoplasm*. Use your text to determine where the following animal cell parts are located: *mitochondria*, *centrioles*, *Golgi bodies*, *endoplasmic reticulum*, *ribosomes*, and *lysosomes*. Draw these parts as they would appear under an electron microscope onto Figure 12-7 and correctly label them.



CELL MEMBRANES AND PERMEABILITY

13

Do all chemical substances pass in and out of a cell membrane with equal ease? Do chemical substances move from areas of high concentration to areas of low concentration as they pass in and out of a cell? What determines what substances can diffuse into a cell? These questions may seem difficult to answer. Sometimes scientists use models to help answer difficult questions. Part of this investigation will use a model of a living cell which will allow you to observe changes that are controlled by the cell membrane.

The cell membrane determines what substances can diffuse into a cell. This characteristic of a cell membrane is called permeability. Many cells are semipermeable. Some substances can pass through the cell membrane, but others cannot. A certain substance, potassium permanganate, can pass through a cell membrane. However, its diffusion into a cell is influenced by its concentration and the time allowed for diffusion.

In this investigation, you will

- use a plastic bag model for a living cell membrane.
- determine if the plastic "membrane" is permeable to starch and iodine.
- determine the effect of time and concentration on the diffusion of potassium permanganate into potato cubes.

Materials

plastic lunch bag
rubber bands or twist ties
test tube rack
100-mL beaker
test tubes—2
graduated cylinder
glass marking pencil (wax)
starch solution
iodine solution
potato

razor blade (single-edge)
small beakers—4
clock or watch with second hand
5% potassium permanganate solution
1% potassium permanganate solution
0.1% potassium permanganate solution
tweezers
metric ruler
water

Procedure

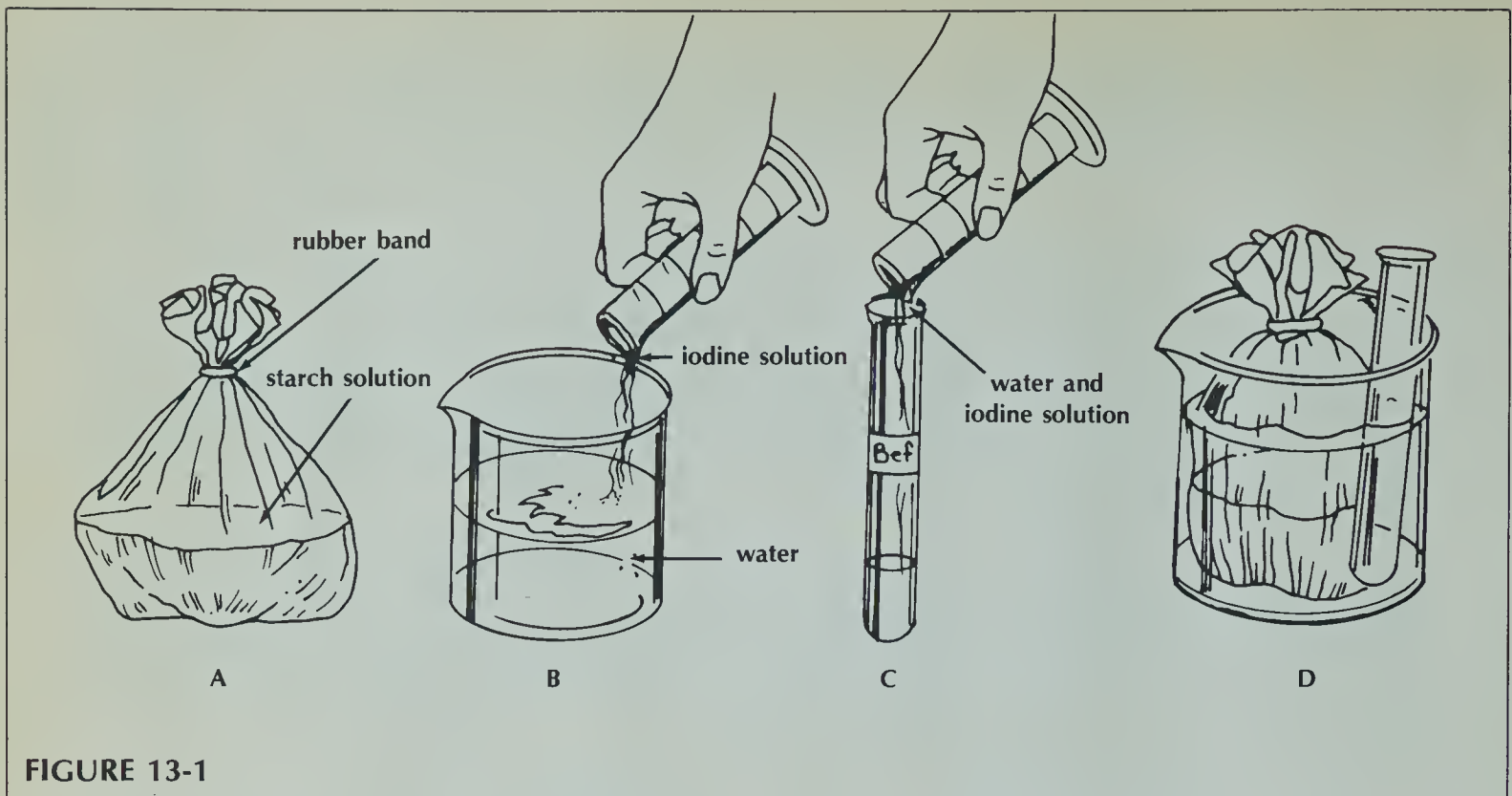
Part A. A Cell Membrane Model

● Fill a plastic lunch bag with 40 mL of starch solution. Seal the top of the bag by twisting the bag and attaching a rubber band or twist tie. The plastic bag filled with starch solution (Figure 13-1A) represents a cell.

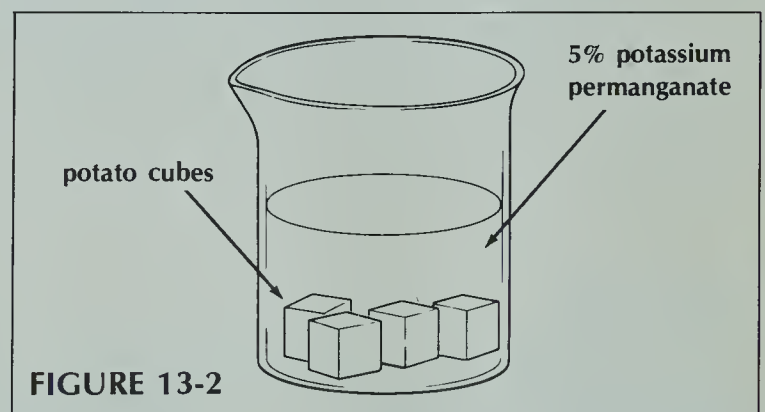
● Note and record in Table 13-1 the exact color of the starch inside the plastic bag cell. Use the "Before" column to record your observation.

● Fill a beaker with 20 mL of water. Add 20 mL of iodine solution to the water. **CAUTION:** *If iodine spillage occurs, rinse with water and call your teacher immediately.* The water and iodine solution represent the environment into which you will place your plastic bag cell. Use Figure 13-1B as a guide.

● Pour some of the water-iodine solution from the beaker into a test tube. Fill the test tube about $\frac{1}{4}$ full. Mark this tube "before." Use Figure 13-1C as a guide.



- Place the plastic bag and test tube into the beaker of iodine solution. Use Figure 13-1D as a guide.
- Put your name on the beaker with a glass marking pencil. Allow the "cell" to stand overnight.
- The next day, remove the plastic bag and test tube and put them aside.
- Pour some of the remaining iodine-water solution from the beaker into a new test tube. Fill the test tube about $\frac{1}{4}$ full. Mark this tube "after."
- Decide which tube, before or after, contains the darker and lighter of the two solutions. Record which solution is darker and which is lighter in Table 13-1.
- Using the "After" column, record in Table 13-1 the color of the starch inside the cell.



Part B. Influence of Time on Diffusion

- With a razor blade, cut five cubes from a potato. Each cube should measure 1 cm on each side.
- Place four of the five cubes into a small beaker half filled with 5% potassium permanganate solution (Figure 13-2). Note the exact time the cubes are added to the solution.

TABLE 13-1. COLOR CHANGES		
	BEFORE	AFTER (NEXT DAY)
Color of starch inside bag (cell)		
Color of iodine outside bag (cell)		

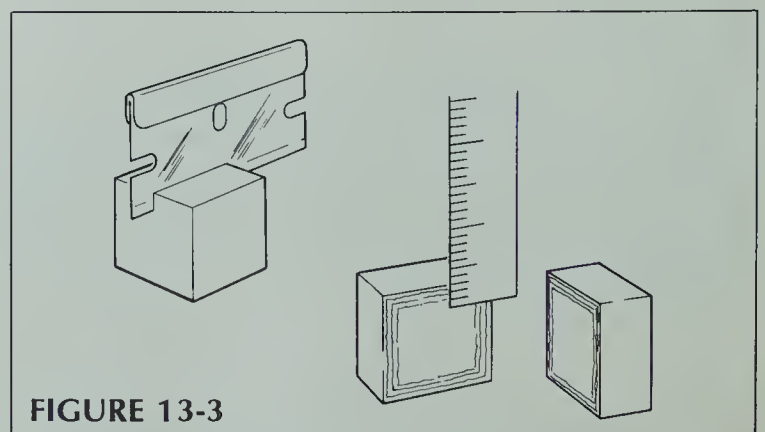


TABLE 13-2. POTATO CUBES IN SOLUTION FOR DIFFERENT LENGTHS OF TIME

CUBE	TIME IN SOLUTION (MIN)	DISTANCE OF DIFFUSION (MM)
1	0	
2	10	
3	20	
4	30	
5	40	

● With tweezers, remove one cube from the solution every ten minutes.

● Slice each cube open with a razor blade (Figure 13-3). **CAUTION:** *Slice away from fingers to avoid cuts.* Carefully dry the razor blade before slicing each cube. Measure the distance in millimetres that the solution has diffused into each potato cube. Distances that you measure may not be very large.

● Record the distance and total time in the solution for each cube in Table 13-2.

● Slice open the cube that was not added to the solution. This cube will be your "control." Consider it as the zero minutes cube (Cube 1) in the table.

Part C. Influence of the Chemical Concentration on Diffusion

● Pour equal amounts of the following liquids into separate beakers:

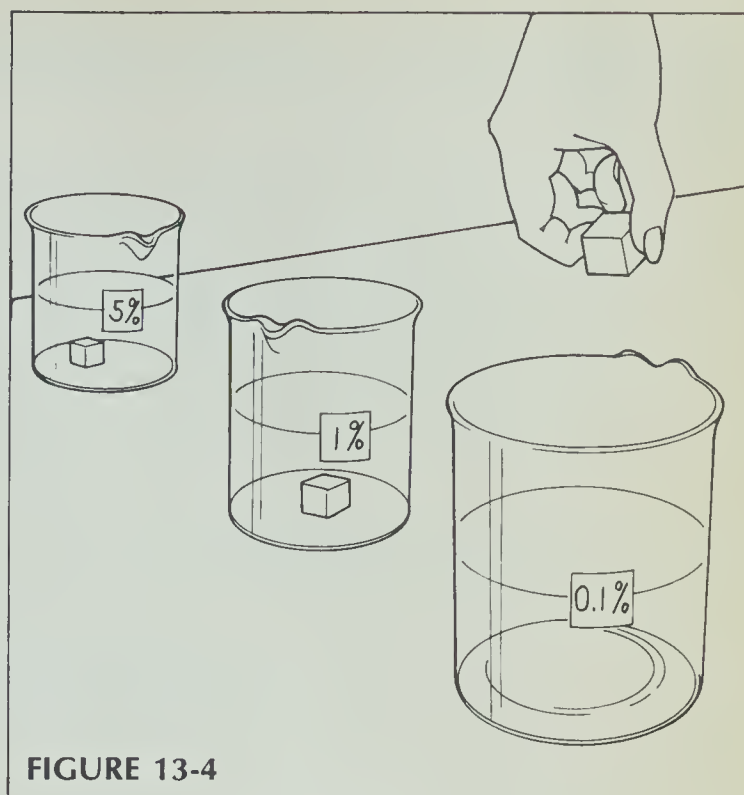
5% potassium permanganate solution

1% potassium permanganate solution

0.1% potassium permanganate solution

Label each beaker as to the strength of liquid being used—5%, 1%, or 0.1%. Record the concentrations in Table 13-3.

● Cut three potato cubes each measuring about 1 cm on a side.

**FIGURE 13-4**

● Place one potato cube into each beaker (Figure 13-4). Note the exact time the cubes are added to the solutions.

● After 40 minutes, use tweezers to remove each potato cube from its solution.

● Slice each cube in half with a razor blade. Carefully dry the blade before slicing each cube.

● Measure the distance in millimetres that the potassium permanganate solution has diffused into each cube.

● Record the distances in Table 13-3.

TABLE 13-3. POTATO CUBES IN SOLUTIONS OF DIFFERENT CONCENTRATIONS

CUBE	CONCENTRATION OF CHEMICAL	DISTANCE OF DIFFUSION
1		
2		
3		

Analysis

1. In Part A, the plastic bag represents what part of an actual cell? _____
2. Recall from an earlier investigation that iodine solution plus starch (or polysaccharide) forms a blue color when mixed together.
 - (a) What color was the starch at the start of the experiment? _____
 - (b) What color was the starch on the next day? _____
 - (c) What did the color change show? _____

3. (a) Did starch move out of the bag? _____
 - (b) What evidence do you see to support your answer? _____

4. (a) Was iodine on the outside lighter in color before or after the experiment? _____
 - (b) If iodine moved into the bag, would its color on the outside become lighter? _____
5. A membrane is permeable to a substance if that substance can move through the membrane. It is impermeable if that substance cannot move through the membrane.
 - (a) Using your experimental results, explain if the bag is impermeable or permeable to iodine.

 - (b) Using your experimental results, explain if the bag is impermeable or permeable to starch.

6. Diffusion results in the movement of chemicals through a permeable cell membrane from areas of high amount or concentration toward areas of low amount or concentration.
 - (a) At the start, was iodine in high or low concentration outside of the bag? _____
 - (b) At the start, was iodine in high or low concentration inside the bag? _____
 - (c) Did iodine move by diffusion? _____
7. Some scientists believe that membranes contain very small pores. Pore size may determine why some chemicals can or cannot pass through a cell membrane. How might the size of the membrane pore compare to the size of
 - (a) the iodine molecules? _____
 - (b) the starch molecules? _____
8. On a separate sheet of paper, write a paragraph which summarizes Part B of this investigation. Include (a) the purpose of Part B, (b) your investigation findings, and (c) how the length of time in the solution influences the amount of diffusion. Use specific values from Table 13-2 to support your statements.
9. On a separate sheet of paper, write a paragraph which summarizes Part C. Include (a) the purpose of Part C, (b) your investigation findings, and (c) how the concentration of a solution influences the amount of diffusion. Use specific values from Table 13-3 to support your statements.

NORMAL AND PLASMOLYZED CELLS

14

Diffusion of water molecules across a cell's outer membrane from areas of high water concentration to areas of low water concentration is called osmosis. This movement of water may be harmful to cells. It can result in cell water loss (plasmolysis) when living cells are placed into an environment where the water concentration inside the cell is higher than outside the cell. However, most cells live in an environment where movement of water in and out of the cell is about equal. Therefore, there are no harmful effects to the cell.

In this investigation, you will

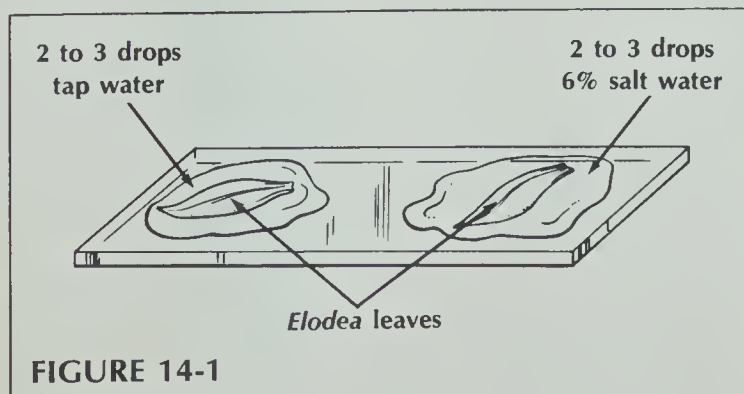
- prepare a wet mount of an *Elodea* leaf in tap water and a wet mount of an *Elodea* leaf in salt water for microscopic observation.
- observe and diagram cells of both wet mounts.
- observe the normal appearance of *Elodea* cells in tap water.
- compare normal cells in tap water to plasmolyzed cells in salt water.

Materials

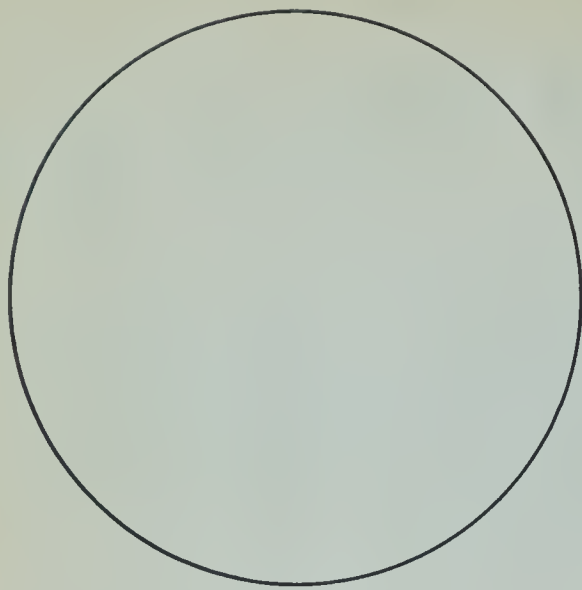
microscope
microscope slide
coverslips
Elodea (water plant)
dropper
water
6% salt solution
tweezers

Procedure

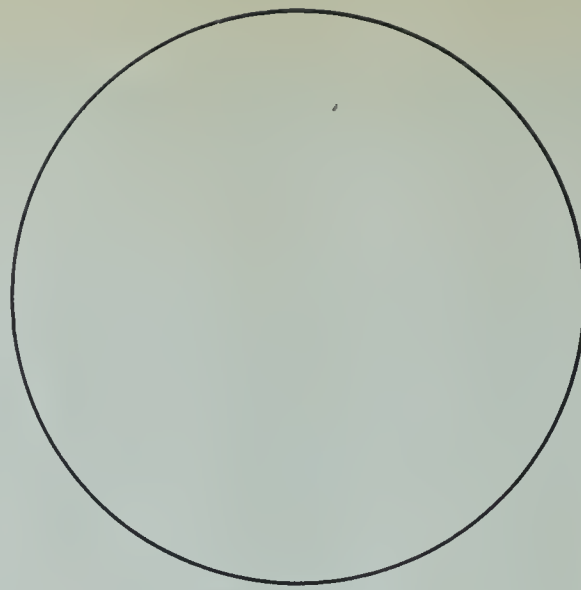
- Prepare a wet mount of two *Elodea* leaves as follows. Use Figure 14-1 as a guide.
- **Step 1.** Put two or three drops of tap water on the left side of the slide.
- **Step 2.** Put two or three drops of 6% salt water on the right side of the slide.



- **Step 3.** Place one *Elodea* leaf in the water on each side of the slide.
- Add coverslips to both leaves. NOTE: Make sure that the two liquids on the slide do not run together. If they do, discard leaves and start over using fewer drops of liquid.
- Wait two or three minutes. Observe each leaf under both low and high powers. To observe both leaves, simply move the slide back and forth across the microscope stage.
- Carefully observe the location of chloroplasts in relation to the cell wall of both leaves.
- Diagram in the space provided a *single cell from each side*. Label the *cell wall*, *cell membrane*, and *chloroplasts* in both cells. (Be careful—can you see the cell membrane in both cells or only in one?)



normal cells



plasmolyzed cells

Analysis

Read the following four statements before answering the questions:

- (a) *Elodea* cells normally contain 1% salt and 99% water on the inside.
- (b) Tap water used in this investigation contains 1% salt and 99% water.
- (c) Salt water used in this investigation contains 6% salt and 94% water.
- (d) Salt water has a higher concentration of salt than fresh water or *Elodea* cells.

1. Describe the location of chloroplasts in a normal *Elodea* cell (in tap water). _____

2. Describe the location of chloroplasts in a plasmolyzed cell (in salt water). _____

3. Answer the following questions about the cell in tap water.

(a) What is the percentage of water outside the cell? _____

(b) What is the percentage of water inside the cell? _____

(c) How do the percentages compare? _____

(d) Did the cell change shape? _____ Explain. _____

4. Answer the following questions about the cell in salt water.

(a) What is the percentage of water outside the cell at the investigation's start? _____

(b) What is the percentage of water inside the cell at the investigation's start? _____

(c) Is the percentage of water (concentration) inside higher or lower than the percentage outside?

(d) When will water move across the cell's membrane? _____

(e) Circle the direction water should move: from high to low or low to high concentration.

(f) Did the inside of the cell change shape due to water loss? _____ Explain. _____

5. What is plasmolysis? _____

MITOSIS

15

A single fertilized human egg cell will divide to form two cells. These two cells will each divide into two cells. In time, millions of cells are produced. The division of nuclear material in which each new cell obtains the same number of chromosomes and the same nuclear code as the original cell is called mitosis. Mitosis occurs in four phases. There is an interphase between each mitosis.

In this investigation, you will

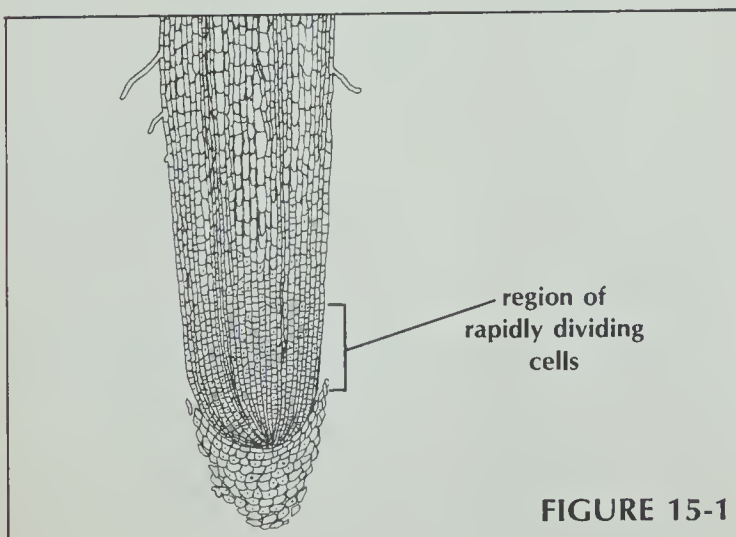
- locate cells in prepared onion root slides that are in the process of dividing by mitosis.
- identify cells in interphase and in each of the four stages of mitosis in the onion root tips by comparing them with diagrams.
- study the changes which occur in a cell as it undergoes mitosis.

Materials

microscope
prepared slides of onion root tip (*Allium*), longitudinal section

Procedure

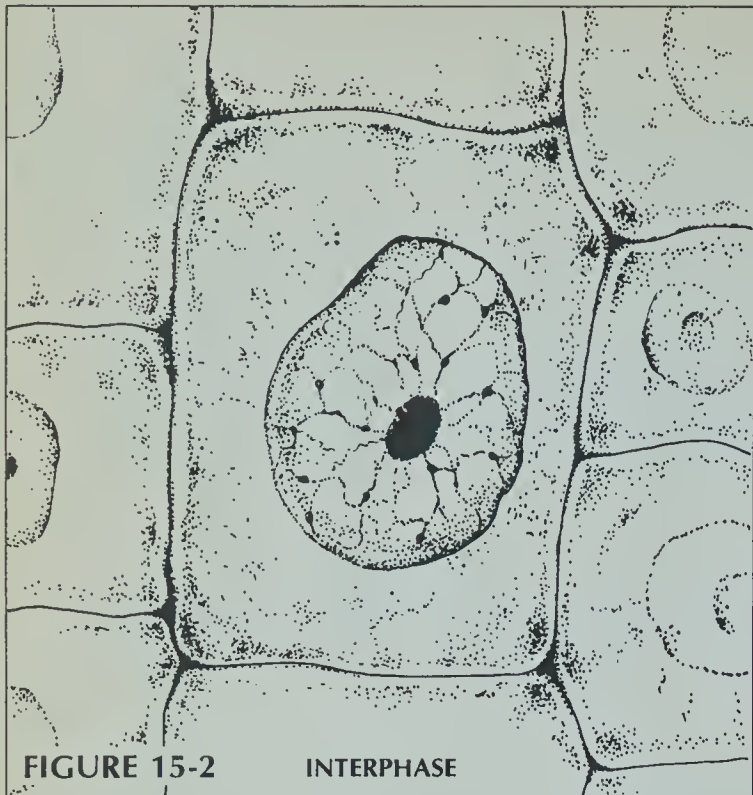
- Locate with a microscope the region of rapidly dividing cells on the prepared slide of onion root tip as shown in Figure 15-1. After locating the cells under low power, switch to high power.
- Answer the following questions about each of the phases of mitosis.



Interphase

- Locate cells resembling Figure 15-2. Answer questions 1-3 while observing these cells.

1. Describe the contents of a nucleus during interphase. _____
2. Are a nucleolus and nuclear membrane present in the cell? _____
3. Are distinct rod-shaped structures called chromosomes easily observed in the nucleus at this time? _____
Use your text for reference while answering questions 4-6.
4. Are chromosomes present in cells during interphase? _____
5. What term is used to describe nuclear contents during interphase? _____

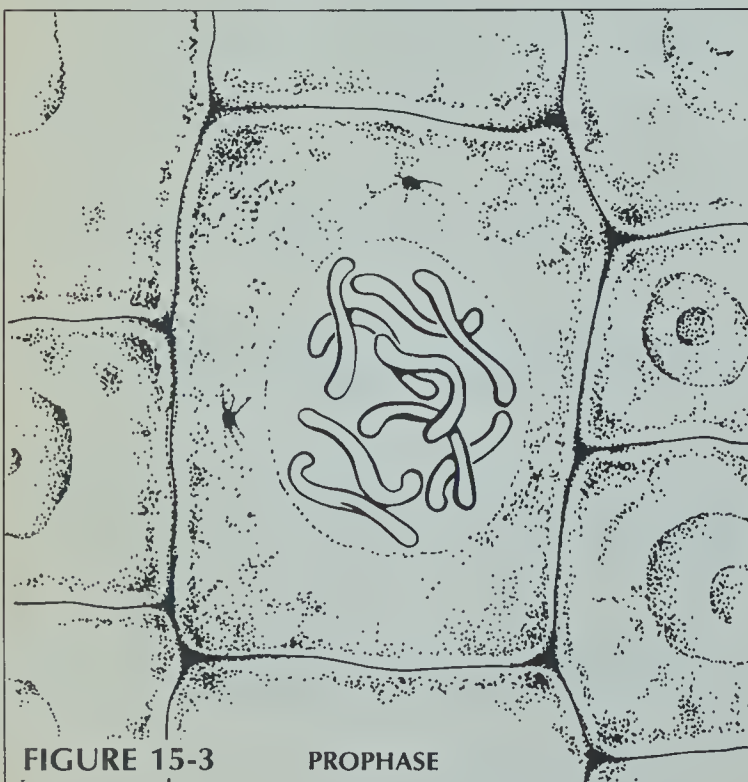


6. (a) What important event occurs to chromosomes during interphase? _____

(b) What other important events occur during interphase? _____

Prophase

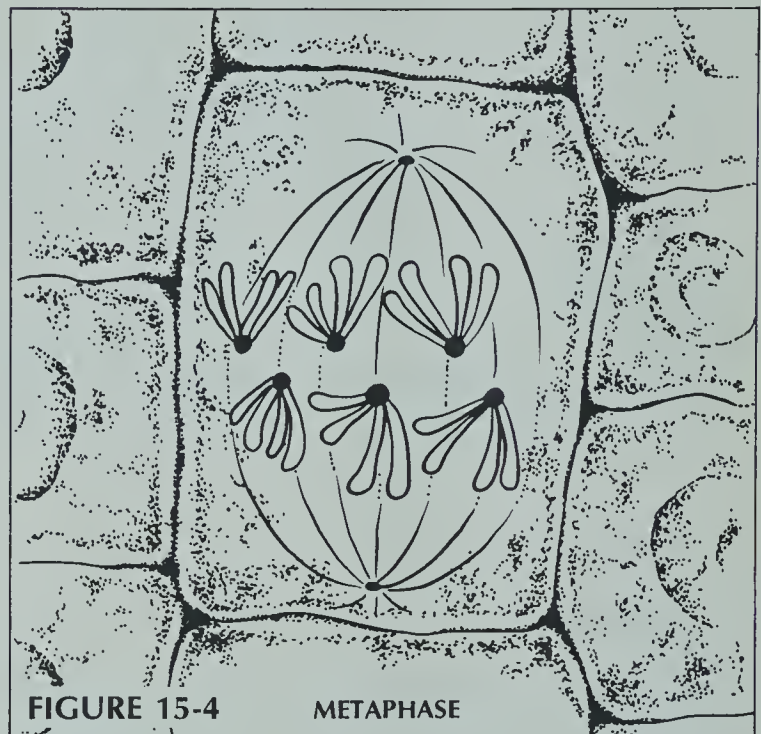
• Locate cells resembling Figure 15-3. Answer questions 7 and 8 while observing these cells.



7. Are chromosomes now visible during prophase? _____
8. Describe the changes that have occurred to the nucleolus and nuclear membrane from interphase to prophase. _____

• Use your text for reference while answering question 9.

9. Explain why chromosomes can now be observed but were not observable during interphase. _____



Metaphase

• Locate cells resembling Figure 15-4. Answer questions 10 and 11 while observing these cells.

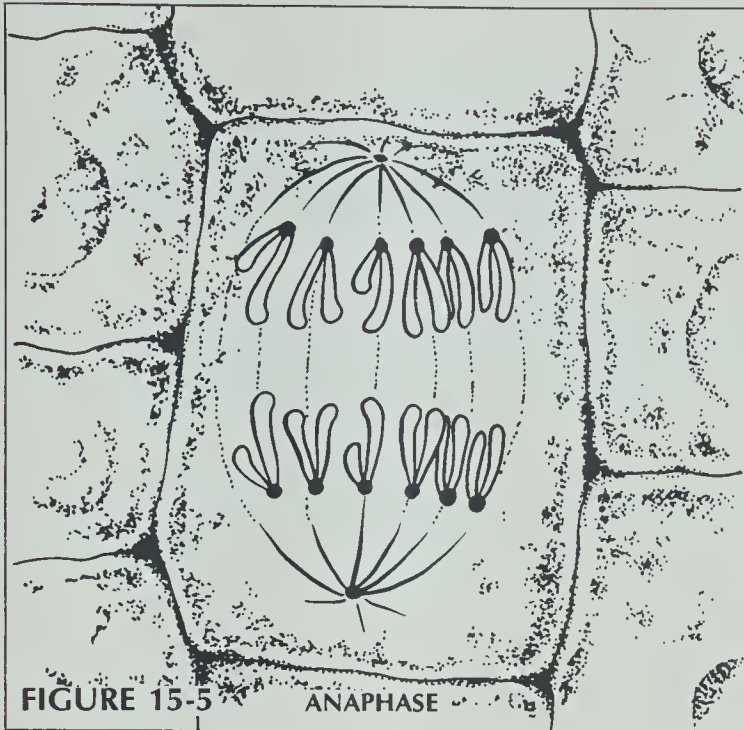
10. Describe where the chromosomes are now located in relation to the cell. _____

11. Can evidence of chromosome duplication (replication) now be observed? _____

• Use your text for reference while answering questions 12 and 13.

12. What are the fibers called that become visible during this phase? _____

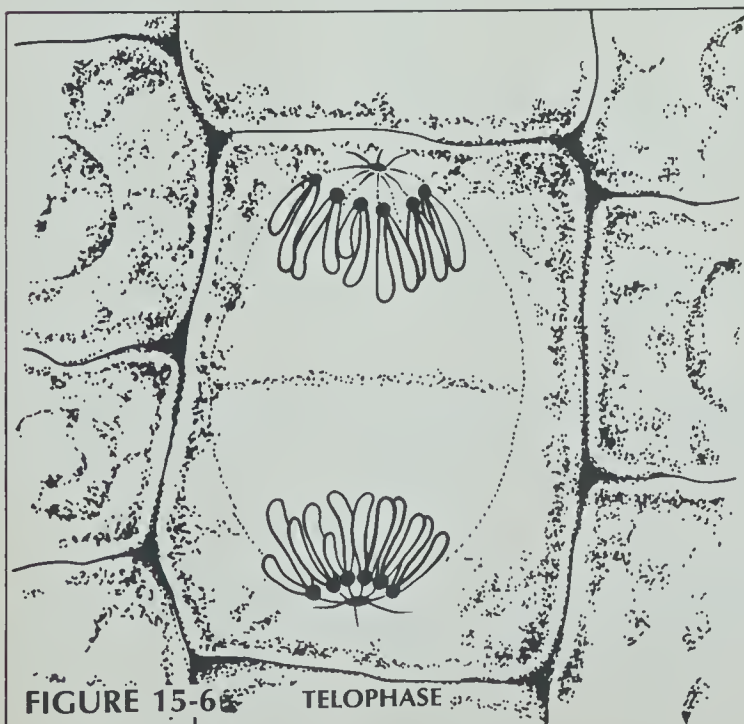
13. What term is used to describe the structure at which each fiber attaches to a chromosome?
- _____



Anaphase

- Locate cells resembling Figure 15-5. Answer questions 14 and 15 while observing these cells.

14. In metaphase, chromosome pairs were lined up along the cell's center. Describe what is occurring to each chromosome pair during anaphase. _____
- _____



15. Toward what area of the cell are the chromosomes being directed? _____

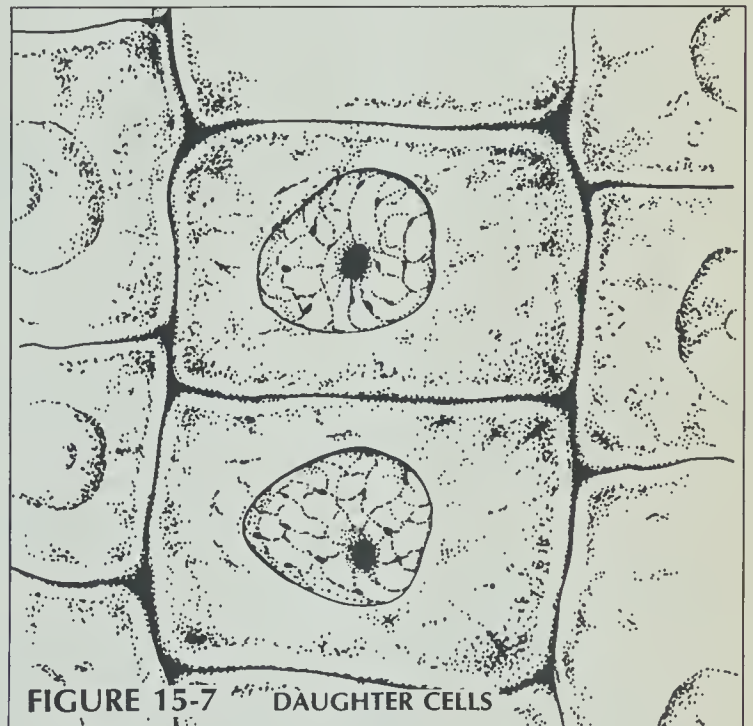
- Use your text for reference while answering question 16.

16. What structure is responsible for the movement of chromosomes during this phase?
- _____

Telophase

- Locate cells resembling Figure 15-6. Answer question 17 while observing these cells.

17. What cell parts begin to reappear during this phase? (See question 8.) _____
- _____



Daughter Cells

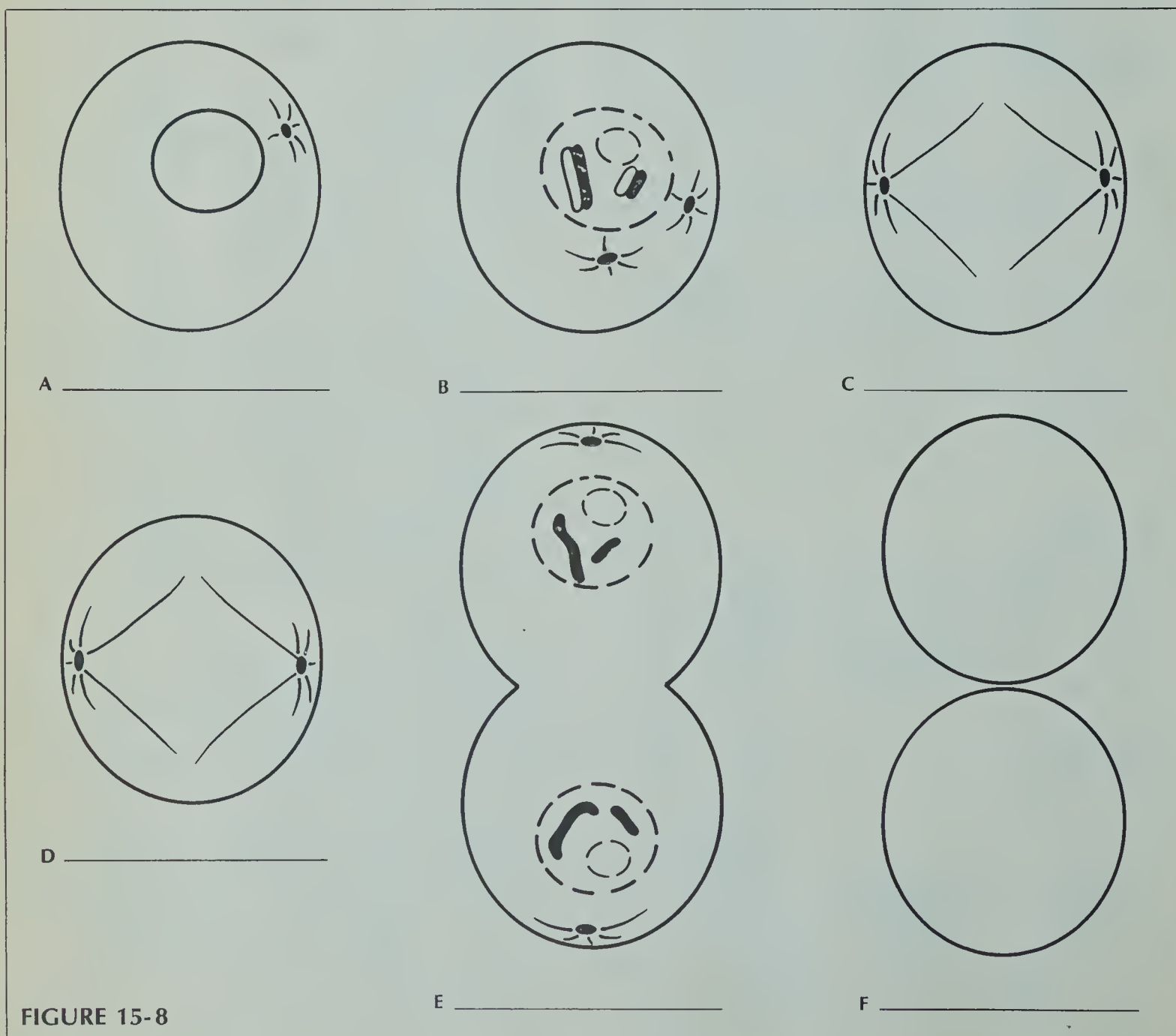
- Locate cells resembling Figure 15-7. Answer questions 18 and 19 while observing these cells.

18. How many cells have now formed from an original cell? _____

19. Explain how the number of chromosomes found in each daughter cell compares to the number found in the original cell before mitosis. (HINT: Read introduction.) _____
- _____

Analysis

1. The term "mitosis" comes from the Greek word meaning "thread." Explain why this word may be helpful in describing this process of nuclear division. _____
2. Explain how the process of mitosis helps an organism to grow in size. _____
3. Complete Figure 15-8 to show the structures visible during each stage of mitosis. Draw in and/or label the structures listed below on the appropriate diagram. Be sure to label each diagram with the correct mitosis stage name.
 - (a) *Interphase*: draw and label *nuclear membrane*, *nucleolus*, *chromatin*.
 - (b) *Prophase*: label *disappearing nuclear membrane*, *disappearing nucleolus*, *original chromosomes* (shaded), *chromosome copies* (unshaded).
 - (c) *Metaphase*: draw in the two chromosome pairs as they would appear during metaphase. Label *chromosomes*, *spindle fibers*.
 - (d) *Anaphase*: draw in the two chromosome pairs as they separate in anaphase. Label *centromeres*.
 - (e) *Telophase*: label *nuclear membrane*, *reforming nucleolus*, *pinching in of cell membrane*.
 - (f) *Interphase*: draw in and label *nucleus*, *nucleolus*, *nuclear membrane*, and *chromatin* in each cell.



TIME FOR MITOSIS

16

Do all phases of mitosis require the same amount of time for completion? This question can be answered by counting the number of onion root tip cells in the four phases of mitosis and in interphase. Many cells in one specific phase indicate that a long period of time is required for completion of that phase. Few cells in a specific phase indicate a short period of time is required for completion of that phase.

In this investigation, you will

- use prepared slides of onion root tip cells to locate cells in mitosis and interphase.
- count the number of cells in each of the phases of mitosis and in interphase.
- compute the length of time in minutes needed to complete each phase.
- compare data of the time needed for normal cells to complete each phase with that of abnormal cancer cells.

Materials

microscope

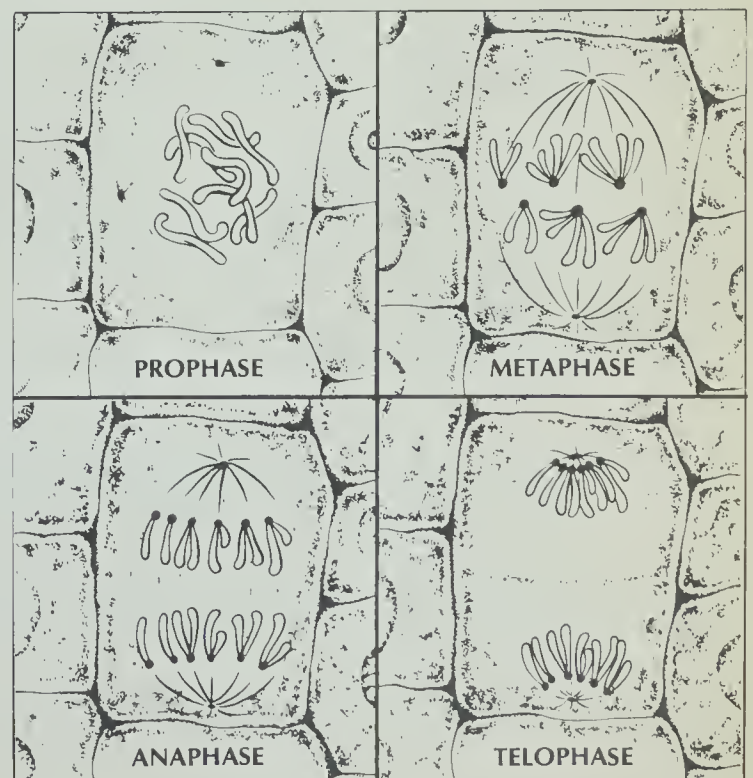
prepared slides of onion root tip (*Allium*), longitudinal section

Procedure

Part A. Locating and Counting Cells in Mitosis

- Locate under the microscope on an onion root tip slide an area with cells in the process of mitosis. After locating the cells under low power, switch to high power.
- Count and record in Table 16-1 the number of cells in each mitotic phase and in interphase. Count all cells in the field of view. Use Figure 16-1 as a guide to the phases of mitosis.
- Move the slide so you are looking at a new area of cells.
- Count and record the number of cells in each mitotic phase and in interphase for this area.
- Repeat for a third new area.
- Total the number of cells counted in each phase and interphase for the three areas. Record this figure in the column marked "Total Number of Cells in Each Phase" of Table 16-1.
- Add the total number of cells viewed in each phase and interphase together to get the total of all cells counted. Record this number in Table 16-1.

FIGURE 16-1



Part B. Determining the Time Required for Each Phase

Assume that the number of cells in a phase is an indication of the time spent in that phase during mitosis. Time spent in a mitotic phase and in interphase can be calculated if the total time for mitosis is known. Onion cells require 12 hours (720 minutes) to complete mitosis (from interphase to interphase). The amount of time needed for a phase can be calculated using the formula:

$$\text{time for a phase} = \frac{\text{number of cells in a phase}}{\text{total number of cells counted}} \times 720 \text{ minutes}$$

For example: If 109 cells were counted in metaphase and 980 total cells were counted, then

$$\frac{109}{980} \times 720 \text{ minutes} = 80 \text{ minutes}$$

- Calculate the time required for each phase of mitosis using your data. Use the total of the three areas counted. Assume that the total time for mitosis is 720 minutes.

- Record the times in Table 16-1.

TABLE 16-1. RESULTS OF COUNTING CELLS IN EACH PHASE OF MITOSIS AND INTERPHASE					
PHASE	FIRST AREA	SECOND AREA	THIRD AREA	TOTAL NUMBER OF CELLS IN EACH PHASE	TIME IN MINUTES
Interphase					
Prophase					
Metaphase					
Anaphase					
Telophase					
			Total number		

Analysis

1. Which phase requires the longest time for completion? _____
2. Which phase requires the next longest time for completion? _____
3. Which phase requires the shortest time for completion? _____
4. The following table shows average times required for normal and diseased chicken stomach cells to complete mitosis.
 - (a) In normal chicken cells, which phase requires the longest time for completion? _____

 - (b) In normal chicken cells, which phase requires the next longest time for completion? _____

 - (c) How do your answers to questions 4a and 4b compare with answers to questions 1 and 2?

TABLE 16-2. TIME FOR MITOSIS OF NORMAL AND CANCEROUS CHICKEN STOMACH CELLS (IN MINUTES)

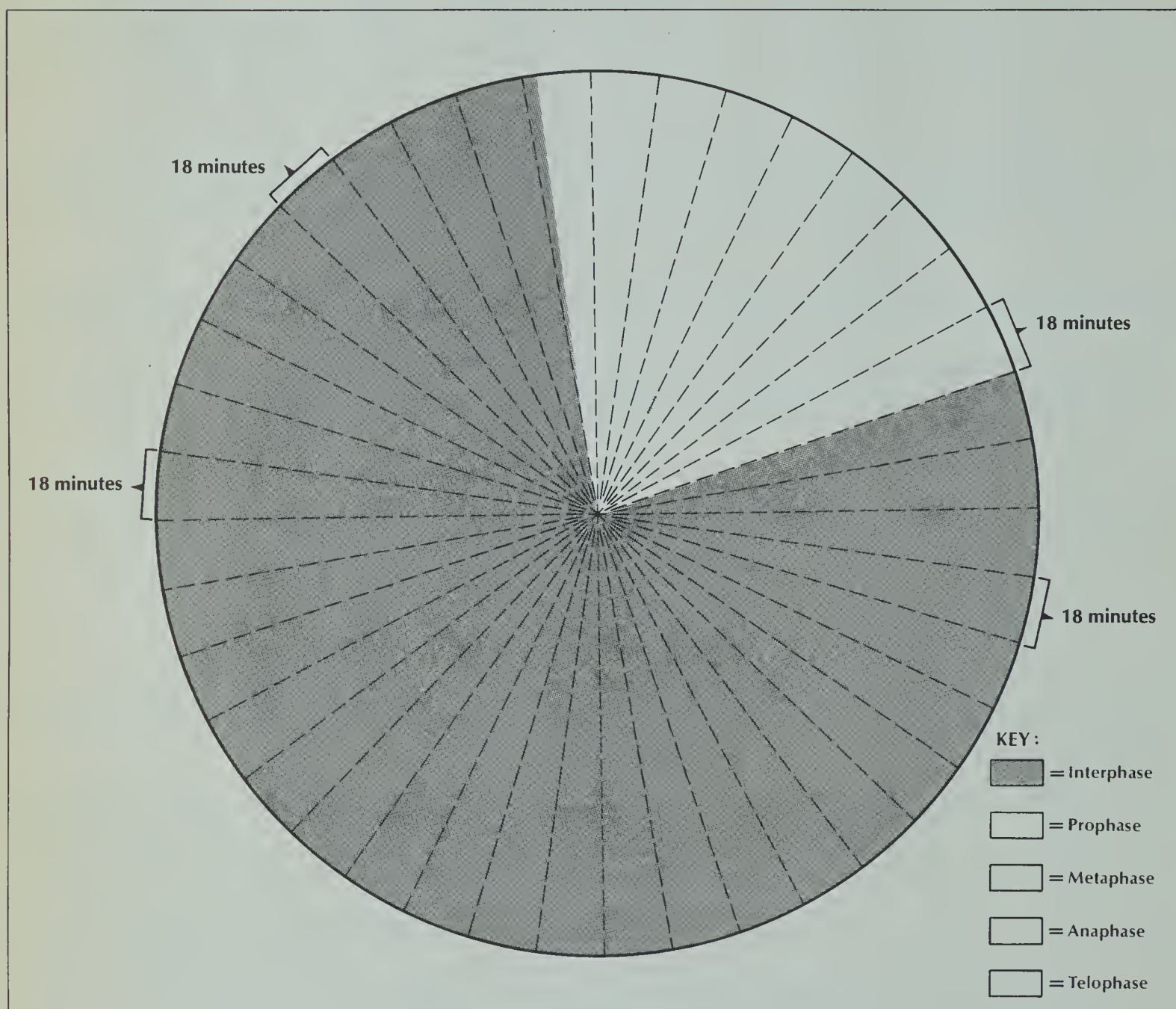
	NORMAL CHICKEN STOMACH CELLS IN MINUTES	CANCEROUS CHICKEN STOMACH CELLS IN MINUTES
Interphase	540	380
Prophase	60	45
Metaphase	10	10
Anaphase	3	3
Telophase	12	10

5. (a) What is the total time needed for a normal chicken stomach cell to complete mitosis? (Total up the time in minutes for each phase.) _____
- (b) What is the total time needed for a cancerous chicken stomach cell to complete mitosis? _____
6. How do cancer cells differ from normal cells in total time required for mitosis? _____
7. How do cancer cells differ from normal cells in time spent for each phase? _____
8. Table 16-3 shows the length of time (in minutes) needed for mitosis to occur in 2 different normal living organisms.
- (a) Which organism, salamander or pea, shows time needed to complete mitosis most like the data you recorded in Table 16-1? _____
- (b) Why might the time required for these two organisms to complete mitosis be similar? (HINT: Where did the cell material you used in Part A come from?) _____

TABLE 16-3. TIMES NEEDED FOR MITOSIS

	PROPHASE	METAPHASE	ANAPHASE	TELOPHASE	TOTAL
Salamander kidney cells	60	50	6	70	186
Pea root cells	80	40	4	12	136

9. Using your data from Table 16-1 and the outline below, prepare a circle graph which shows the number of minutes that onion cells spend in each phase of mitosis. The following suggestions may aid you in preparing your graph.
- Graph your data using the "Time in minutes" column from Table 16-1.
 - The circle is divided into 18 minute sections. Each section of the graph equals 18 minutes. If a phase is not exactly 18 minutes long (or some interval close to a multiple of 18 minutes), approximate the position of the line on the graph.
 - Shade each phase on your graph with colored pencils or various degrees of pencil shading.
 - Identify each phase by shading the key to correspond with the shading on your graph.



10. Refer to the outline graph above when answering the following questions.
- What important changes occur in the nucleus and cell during the longest phase of mitosis?

- Why do you think so much time is spent in this phase?

COMPARING MITOSIS AND MEIOSIS

17

Your body carries out two different kinds of nuclear division. One is called mitosis and results in formation of new body cells for growth and repair. A second process is called meiosis and results in formation of reproductive cells only. There are several important differences between mitosis and meiosis.

In this investigation, you will

- (a) compare the process of mitosis with meiosis.
- (b) use model diagrams to show changes in cells during mitosis and meiosis.

Materials

pages of cell outlines
4 wool strands (18 mm long)
4 wool strands (30 mm long)

Procedure

Part A. Mitosis

Your teacher will supply you with outline diagrams for Part A of this experiment. Use only diagrams A, B, and C for Part A.

- Place the diagrams one below the other in proper order on your desk.

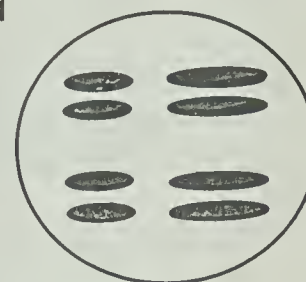
- Diagram A represents the outline of a cell before cell division or mitosis begins. Chromosomes are present inside the nucleus (but usually cannot be seen). Use wool strands to represent chromosomes. NOTE: A cell may contain many chromosomes. You will use only 4 chromosomes to help simplify this study.

- Place two long and two short pieces of wool (chromosomes) onto diagram A.

1. What is the total number of chromosomes present in this cell before mitosis? _____
2. How many long chromosomes are present before mitosis? _____
3. How many short chromosomes are present before mitosis? _____

- Before the cell begins mitosis, each chromosome makes an exact copy of itself. This process is called chromosome replication.

FIGURE 17-1



chromosome replication

- To show chromosome replication, match new strands of wool with each original. Long should match with long, short with short (Figure 17-1).

- Transfer your chromosomes to diagram B, and position them within the dashed outlines. During mitosis, doubled chromosomes line up along the cell's center.

4. What differences (if any) are there between the original and replicated (copy) part of each chromosome? _____

Doubled chromosomes now separate, and each part is pulled toward one end of the cell.

- Move those chromosomes lined up along the left side toward the cell's left. Move those chromosomes lined up along the right side toward the cell's right. Use the arrows as guides.

- Once the doubled chromosomes separate, the original cell begins to pinch in half down the center. This process forms two new cells.

- Move the chromosomes on the left side of diagram B to the left cell of diagram C.

- Move the chromosomes on the right side of diagram B to the right cell of diagram C.

5. What is the total number of chromosomes present in each cell after mitosis (diagram C)? _____

6. How many long chromosomes are present in each new cell? _____

7. How many short chromosomes are present in each new cell? _____

8. Compare your answers in questions 1-3 to those in questions 5-7. Are the two new cells just formed the same in chromosome makeup as the original cell? _____

In summary, some important things about mitosis include:

- (a) every new cell formed has the same chromosome number,
- (b) every new cell formed has the same chromosome number as the original cell,
- (c) mitosis occurs in all body cells (somatic cells), and
- (d) mitosis is responsible for growth and cell repair.

Part B. Meiosis

- Your teacher will supply you with outline diagrams for Part B of this experiment. Use only diagrams D, E, F, and G for Part B. Place the diagrams one below the other in proper order on your desk.

- Diagram D represents the outline of a cell before meiosis begins. Chromosomes are present inside the cell. Place two long and two short pieces of wool (chromosomes) onto cell diagram D.

9. What is the total number of chromosomes present in this cell before meiosis? _____

10. How many long chromosomes are present before meiosis? _____

11. How many short chromosomes are present before meiosis? _____

12. Check back to questions 1-3. Are there differences so far between mitosis and meiosis? _____

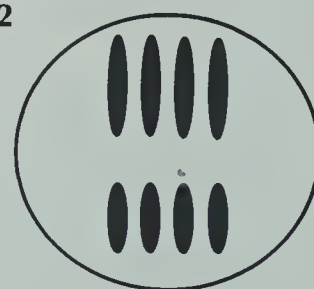
Before meiosis begins, the chromosomes replicate.

- Match new strands of wool with each original. Long should match with long, short with short. Before transferring your chromosomes to diagram E, one important step that is different in meiosis now occurs. One doubled long chromosome now pairs with the other doubled long chromosome.

- Place the four long chromosomes together.

- Do the same for the four short chromosomes which also pair at this stage. Each group of four is now called a tetrad (tetra = 4) (Figure 17-2).

FIGURE 17-2



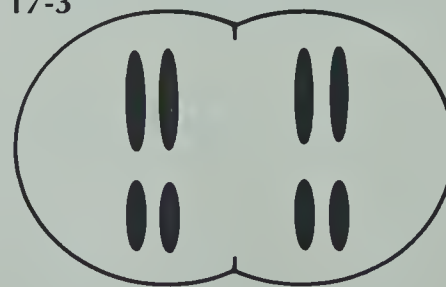
chromosome tetrads

13. Did this step occur in mitosis? _____

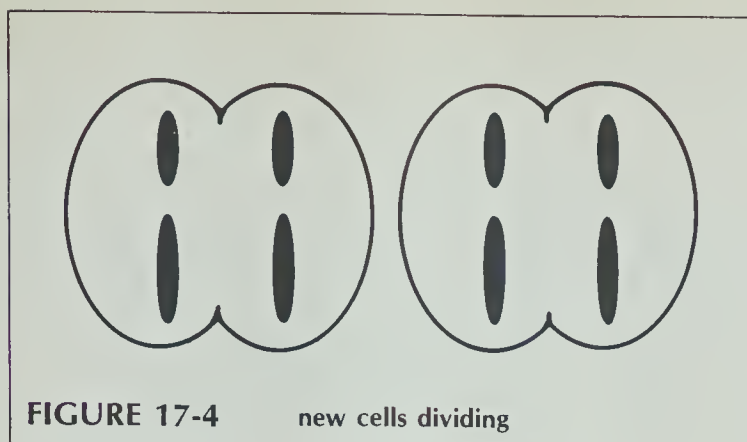
- Place your chromosome tetrads onto diagram E. Use the chromosome outlines to properly position them. During meiosis, the chromosome tetrads line up along the cell's center.

Chromosomes now separate and are pulled toward opposite ends of the cell. They separate, however, in a certain way. Each tetrad separates into the two original doubled chromosomes (Figure 17-3).

FIGURE 17-3



separating tetrads



● Move the doubled chromosomes toward opposite cell ends. Move those pairs lined up along the left center toward the left side of the newly forming cell. Follow the arrows as guides.

● Move the pairs lined up along the right center toward the right side of the newly forming cell. Follow the arrows as guides. Two new cells are formed as the original cell (Figure 17-3) pinches into two.

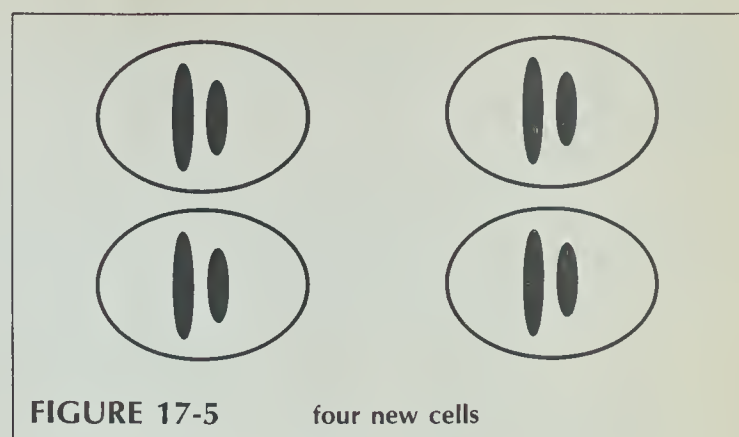
● Transfer those chromosomes on the right side of diagram E to the right circle of diagram F and position them within the dashed lines. Move those on the left side of diagram E to the left circle of diagram F and position them within the dashed lines.

14. (a) How many chromosomes are now present in each cell? _____

(b) How many chromosomes were present in the original cell? _____

(c) Is this step different from that which occurs after two cells form in mitosis? _____

Each new cell just formed, quickly begins to divide again into two new cells (Figure 17-4). This step results in four new cells being formed from the original cell (Figure 17-5). The doubled chromosomes then separate leaving each new cell with a reduced number of chromosomes.



● Move your chromosomes from diagram F to diagram G. Position the chromosomes within the dashed lines.

15. (a) How many new cells are formed from one cell by meiosis (diagram G)? _____

(b) Does this step differ from mitosis? _____

_____ Explain. _____

16. (a) What is the total number of chromosomes present in each new cell after meiosis? _____

(b) Do any of the four new cells contain two long or two short chromosomes? _____

In summary, some important things about meiosis include:

- (a) every new cell formed by meiosis has half the number of chromosomes as the original cell,
- (b) no paired chromosomes are present,
- (c) meiosis occurs only in reproductive organs, and
- (d) meiosis is responsible for forming egg and sperm (gamete) cells.

Analysis

- How many pairs of chromosomes are in each human body (somatic) cell? _____
- How many pairs of chromosomes are in each egg or sperm? (Be careful.) _____

3. In the exercise just completed,

(a) are the chromosomes in pairs in the new cells? _____

(b) how does this differ from the process of mitosis? _____

4. In humans, 46 chromosomes are in each body (somatic) cell, and 23 chromosomes are in each reproductive cell. In the chart below, fill in the chromosome number and process for each cell type.

CELL TYPE	NUMBER OF CHROMOSOMES IN CELL	PROCESS USED TO MAKE CELL (MITOSIS OR MEIOSIS)
stomach		
liver		
sperm		
heart		
egg		

5. Complete the following chart by checking the process of cell division in which each step occurs.

	MITOSIS	MEIOSIS
Two new cells are formed from each original		
Four new cells are formed from each original		
Replication of chromosomes occurs		
Doubled chromosomes pair to form tetrads		
Cells with a reduced chromosome number are formed		
Cells with the same chromosome numbers as original are formed		
Results in forming egg or sperm cells		
Results in forming somatic or body cells		
Each original cell divides only once		
Each original cell divides twice		
Tetrads are not formed		
Chromosomes move to the cell's center		

FINDING GENOTYPES AND PHENOTYPES FOR ONE TRAIT

18

In genetics, it is possible to calculate the results that should appear in offspring if the genotypes of both parents are known. These are called expected results. Expected results can be calculated by mathematics or use of Punnett squares. Thus, expected results are specific numbers and are not the result of random events. Observed results are those that appear in offspring in actual crossings. They are due to chance combinations of certain genes. Thus, observed results are always due to chance.

Expected and observed results may not always agree exactly, but there should be some agreement. Expected results are used to predict the results of a cross before the cross is done. If the expected results indicate that a certain type of offspring is likely, the cross can be carried out with some certainty that the type of offspring will appear in the observed results.

In this investigation, you will

- substitute properly marked coins for gamete cells.
- toss the marked coins 100 times to represent 100 offspring.
- determine the expected numbers of genotypes for 100 offspring and compare them with the observed numbers of genotypes obtained through 100 coin tosses.
- determine the numbers of expected phenotypes for a genetic cross, and compare them with the numbers of observed phenotypes obtained through coin tossing.

Materials

2 pennies
adhesive tape
pencil
scissors

Procedure

Part A. Determining Numbers of Expected Genotypes

How many of each genotype combination are expected in the offspring of a cross if both parents are Ss for a trait?

FIGURE 18-1

	s	s
s		
s		

● Use the Punnett square in Figure 18-1 to determine the genotypes. Record the number of each genotype in column A of Table 18-1.

● How many of each genotype combination are expected if there are 100 offspring? Multiply each number in column A by 25. Record this number in column B of Table 18-1.

Part B. Determining Numbers of Observed Genotypes

● Cover both sides of two pennies with adhesive tape. Trim off any excess tape with scissors. **CAUTION:** Always be careful with scissors. Print an S on one side of each coin and an s on the other side of each coin.

- Place both coins in cupped hands, shake, and then toss the coins onto your desk. Read and record the letter combination in column C (Toss Results) of Table 18-1. Make a slash (/) in the proper row of column C to indicate the letter combination. Repeat this process until the coins have been tossed 100 times. Record the coin combinations for each toss in Table 18-1.
- Record in column D the totals for each.

Part C. Determining Numbers of Expected Phenotypes

- Assume that *S* represents the dominant gene for normal skin pigment. Assume that *s* represents a recessive condition called albinism, no skin pigment. From the Punnett square (Figure 18-1),

list in column A of Table 18-2 the number of offspring expected to have normal skin color (*SS* and *Ss*) and the number expected to be albino (*ss*).

- Calculate the number expected to have each trait if there are 100 offspring. Do this by multiplying column A figures by 25. Record these numbers in column B of Table 18-2.

Part D. Determining Numbers of Observed Phenotypes

From your data in column D of Table 18-1, total and record in column C of Table 18-2 the number of offspring who will have normal skin pigment (*SS*, *Ss*, and *sS*) and those who will be albino (*ss*).

TABLE 18-1. EXPECTED AND OBSERVED GENOTYPES				
GENE COMBINATION	(A) EXPECTED GENOTYPE FOR 4 OFFSPRING	(B) EXPECTED GENOTYPE FOR 100 OFFSPRING	(C) TOSS RESULTS	(D) OBSERVED GENOTYPE FOR 100 OFFSPRING
<i>SS</i>				
<i>Ss</i> or <i>sS</i>				
<i>ss</i>				

TABLE 18-2. EXPECTED AND OBSERVED PHENOTYPES			
PHENOTYPE POSSIBLE	(A) EXPECTED PHENOTYPE FOR 4 OFFSPRING	(B) EXPECTED PHENOTYPE FOR 100 OFFSPRING	(C) OBSERVED PHENOTYPE FOR 100 OFFSPRING
Normal Skin (<i>SS</i> , <i>Ss</i> , or <i>sS</i>)			
Albino (<i>ss</i>)			

Analysis

- (a) What is meant by expected genotypes? _____
 - (b) Are expected results due to chance or are they arrived at mathematically? _____
- (a) What is meant by observed genotypes? _____
 - (b) Are observed results due to chance or are they arrived at mathematically? _____
- What does each side of each coin represent? _____

4. How does the chance of a coin landing on each side compare to the chance that a gamete cell will receive a particular gene at meiosis? _____
5. (a) Why must two coins be used to determine the genotypes for the offspring? _____

- (b) What does the use of two coins compare to at fertilization? _____

6. Compare the expected genotypes of 100 offspring with the observed genotypes.
(a) Do they agree or disagree? _____
(b) If they disagree, how much do they disagree? _____
7. Are your results wrong if they do not agree? _____ Explain. _____

8. What is the advantage of comparing the 100 expected offspring with the 100 observed offspring rather than comparing only four expected offspring with four observed offspring? _____

9. Compare the expected phenotypes for 100 offspring with the observed phenotypes.
(a) Do they agree or disagree? _____
(b) If they disagree, how much do they disagree? _____
10. Are your results wrong if they do not agree? _____ Explain. _____

11. If expected and observed results are never in close agreement, then our understanding of the law of dominance and the chance combination of genes cannot be correct.
(a) Are expected and observed results in close agreement after many offspring are counted? _____
(b) Does our understanding of genetics seem to have support as illustrated in this investigation? _____

(c) Would you have good evidence if only one or two offspring were examined? _____
(d) Explain. _____
12. Class totals also may be used to show that expected and observed results will agree more closely when large numbers of offspring (coin flips) are counted. Record the total number of students participating in this investigation at the top of Table 18-3. Using expected phenotype data for 100 offspring from Table 18-2 (column A), record this same number in column A of Table 18-3. Determine and record in Table 18-3 the class total of expected phenotypes (column B) by multiplying column A by the number of students participating. In column C, record class totals from all students of observed phenotypes for 100 offspring from column C of Table 18-2.

TABLE 18-3. CLASS TOTALS OF _____ STUDENTS			
	(A) EXPECTED PHENOTYPES FOR 100 OFFSPRING	(B) EXPECTED PHENOTYPES FOR CLASS TOTALS	(C) OBSERVED PHENOTYPES FOR CLASS TOTALS
Normal skin	75		
Albino skin	25		

13. What is the advantage of comparing expected offspring with the many hundreds of observed offspring (class totals)? In other words, what is the advantage of a large sample size? _____

14. A number of actual families were observed that had albino children. All parents of the families had normal skin but were hybrid. The following figure shows the offspring. NOTE: A square represents a son, a circle represents a daughter, and shading indicates an albino. For example, family A has six children, two boys and four girls. One son is albino and the other five children are normal.

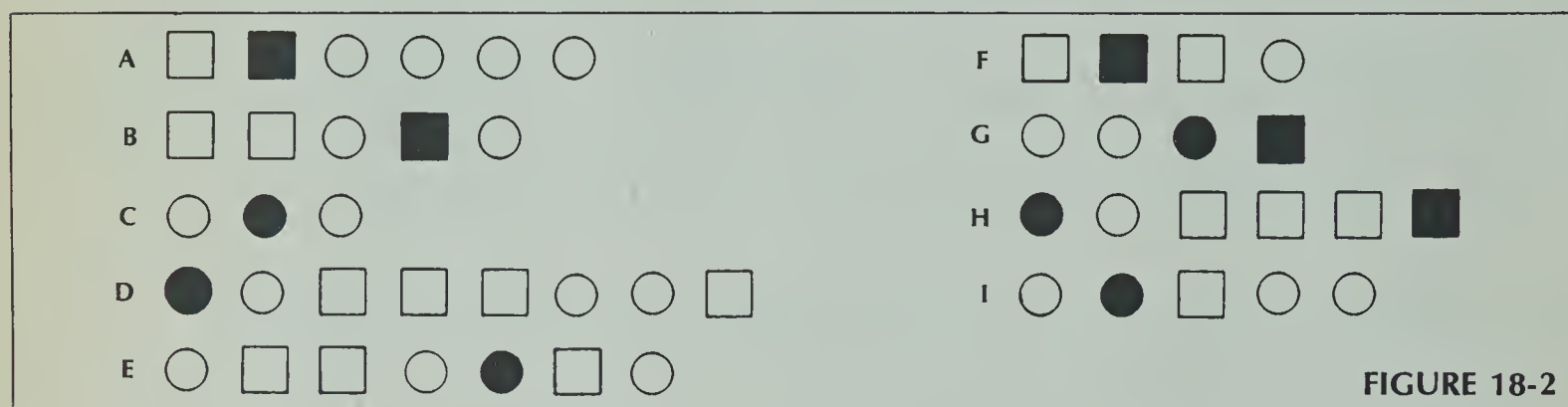


FIGURE 18-2

- What is the total number of children observed in all families? _____
- What is the total number of normal children observed in all families? _____
- How many children are expected to be normal in all families above? (Multiply answer to question (a) by 0.75 or 3/4.) _____
- Are your answers to questions (b) and (c) in close agreement? _____
- What is the total number of albino children observed in all families? _____
- How many children are expected to be albino in all families above? (Multiply answer to question (a) by 0.25 or 1/4.) _____
- Are your answers to questions (e) and (f) in close agreement? _____
- If only families D and E were used, would there be close agreement between observed and expected numbers of albinos? _____
- Is our understanding of genetics supported when observed results from these families are compared to expected results? _____

FINDING GENOTYPES AND PHENOTYPES FOR TWO TRAITS

19

In genetics, a Punnett square is used to show the chances that certain traits will appear in offspring. If only one trait is involved, a Punnett square with four boxes is used. If two traits are involved, then a sixteen box Punnett square is needed. A Punnett square always gives you the expected results. Offspring, however, are produced by chance and may not agree exactly with expected results.

In this investigation, you will

- substitute properly marked coins for gamete cells and toss the coins to represent offspring.
- determine the expected offspring and compare it to observed offspring obtained through coin tossing.
- write a report based on your data explaining the similarity or dissimilarity of expected and observed results and how sample size affects results.

Materials

adhesive tape
scissors
pencil
pennies—2
nickels—2

Procedure

Part A. Cross Between Genotypes *AaMm* and *Aamm*




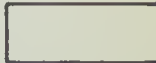
Expected Results

The Punnett square in Figure 19-1 represents a cross involving two characteristics, skin pigment and body height. The parents' genotypes are *AaMm* and *Aamm*. The gene *A* is for normal skin pigment. The gene *a* is for albinism (no pigment). The gene *M* is for normal body height. The gene *m* is for short height (midget).

The Punnett square shows the possible gametes of each parent and the possible offspring. The squares are shaded according to phenotype.

- Determine the four phenotypes and how many offspring of each there are.
- Record these numbers in the "Number expected for 16 offspring" column of Table 19-1. To calculate the number expected for 96 offspring

FIGURE 19-1

		<i>AaMm</i> X <i>Aamm</i>			
		AM	Am	aM	am
Am		<i>AA</i> Mm	<i>AA</i> mm	<i>Aa</i> Mm	<i>Aa</i> mm
am		<i>Aa</i> Mm	<i>Aa</i> mm	<i>aa</i> Mm	<i>aa</i> mm
Am		<i>AA</i> Mm	<i>AA</i> mm	<i>Aa</i> Mm	<i>Aa</i> mm
am		<i>Aa</i> Mm	<i>Aa</i> mm	<i>aa</i> Mm	<i>aa</i> mm
					
		normal skin and height	normal skin, midget	albino, normal height	albino, midget

multiply each number just recorded by 6. Record these new numbers in the "Number expected for 96 offspring" column of Table 19-1.

Observed Results

- Cover both sides of two pennies and two nickels with adhesive tape. **CAUTION:** Always be careful with scissors.
- Mark the four coins as shown in Figure 19-2.
- Toss the four coins (two pennies in one hand, two nickels in the other) onto your desk a total of 96 times.
- Read the genotypes that appear and record the phenotypes in Table 19-1. (Use the Punnett square as a guide if necessary.) Make a slash (/) in the

proper row to indicate the phenotype represented by the coins.

- Place the totals for each phenotype in the proper column of Table 19-1.

Part B. Cross Between Genotypes $AaMm$ and $AaMm$

Expected Results

The Punnett square in Figure 19-3 represents a cross between parents which are heterozygous for skin pigment and body height. As in Part A, the Punnett square shows gametes and possible offspring. Also, the squares are shaded according to phenotype.

- Determine the four phenotypes and how many offspring of each there are.

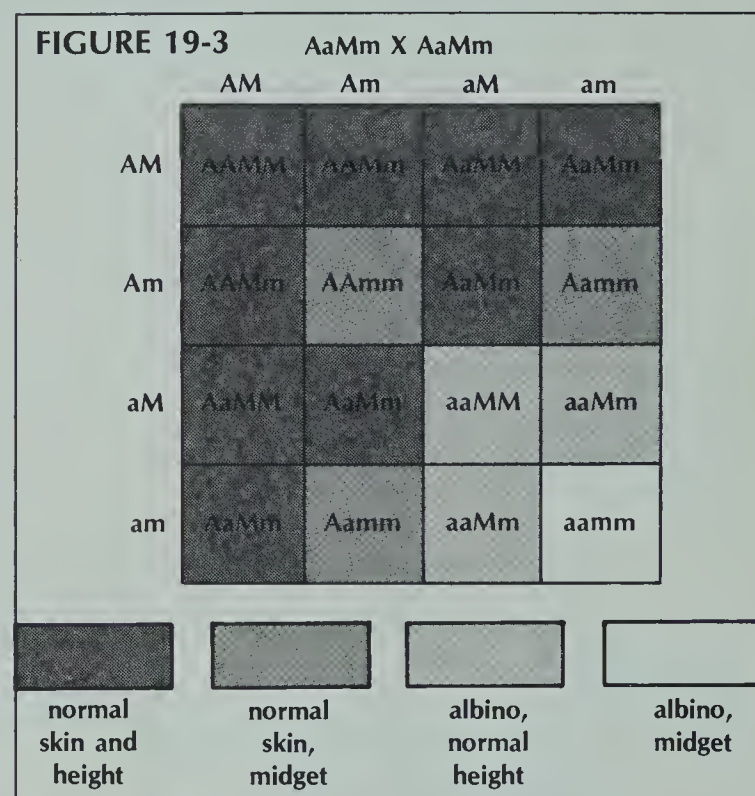
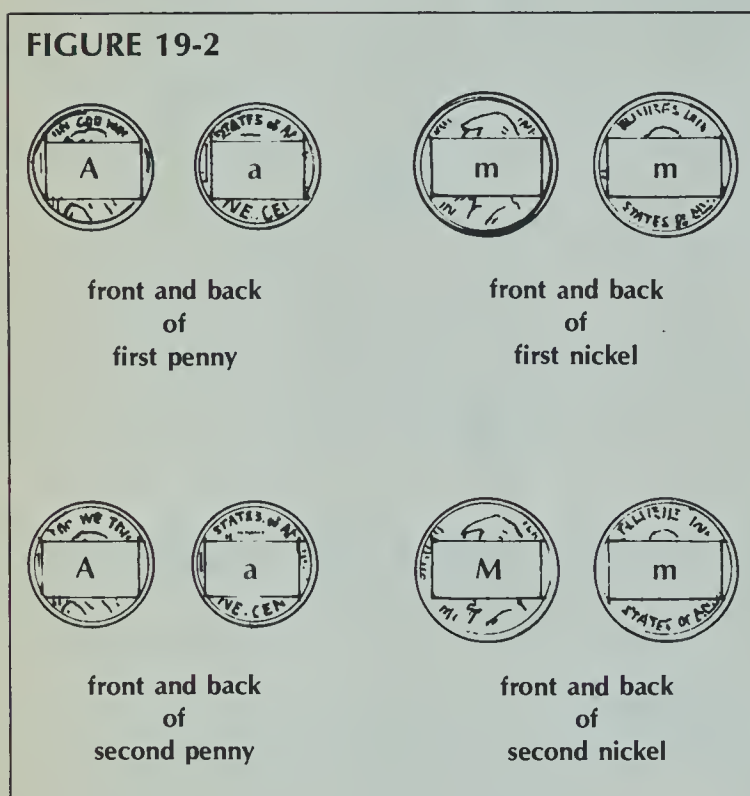


TABLE 19-1. RESULTS OF CROSS BETWEEN $AaMm$ and $Aamm$

PHENOTYPE COMBINATIONS	GENOTYPES	NUMBER EXPECTED FOR 16 OFFSPRING	NUMBER EXPECTED FOR 96 OFFSPRING	TOSS RESULTS	TOTAL NUMBER OBSERVED
Normal skin and normal height	$AAMm$ $AaMm$				
Normal skin but midget	$AAMm$ $Aamm$				
Albino but normal height	$aaMm$				
Albino and midget	$aamm$				

- Record these numbers in the "Number expected for 16 offspring" column of Table 19-2. To calculate the next column, multiply each number just recorded by 6. Record these new numbers in the "Number expected for 96 offspring" column of Table 19-2.

Observed Results

- Use the four coins from the first cross but change the nickel with *m* on both sides so that it has an *M* on one side. The coins should match Figure 19-4.
- Toss the four coins a total of 96 times.
- Read the genotypes that appear and record the phenotypes in Table 19-2.
- Place the totals for each phenotype in the proper column of Table 19-2.

FIGURE 19-4

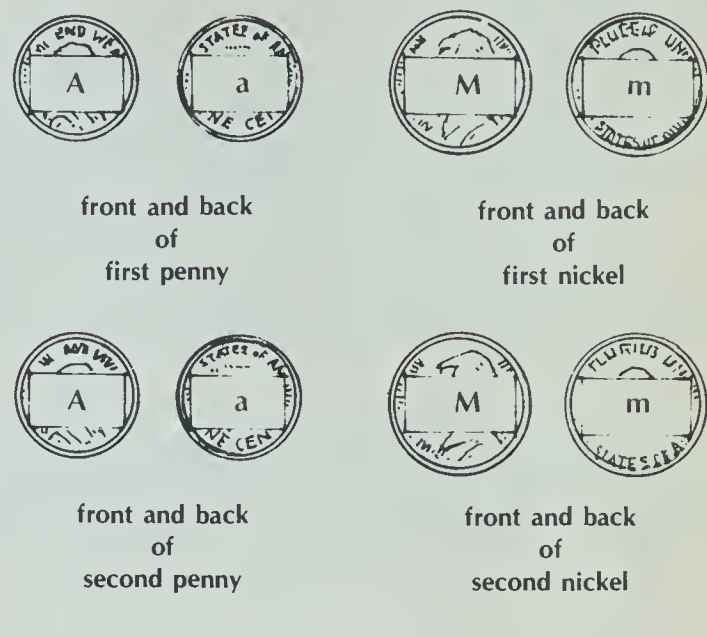


TABLE 19-2. RESULTS OF CROSS BETWEEN *AaMm* and *AaMm*

PHENOTYPE COMBINATIONS	GENOTYPES	NUMBER EXPECTED FOR 16 OFFSPRING	NUMBER EXPECTED FOR 96 OFFSPRING	TOSS RESULTS	TOTAL NUMBER OBSERVED
Normal skin and normal height	<i>AAMM</i> <i>AAMm</i> <i>AaMM</i> <i>AaMm</i>				
Normal skin but midget	<i>AAmm</i> <i>Aamm</i>				
Albino but normal height	<i>aaMM</i> <i>aaMm</i>				
Albino and midget	<i>aamm</i>				

Analysis

Summarize this investigation by writing a report on separate paper that includes

- the purpose of the investigation.
- (a) how the number of expected offspring in a genetic cross can be determined.
(b) the exactness of expected results.
(c) how the number of observed offspring in a genetic cross can be determined.
(d) the exactness of observed results.
- (a) how the number of expected offspring for Part A compares to the observed offspring for Part A. (Use specific data for your comparison.)
(b) why the numbers in these two columns may not be equal.
- how Part A supports our understanding of genetics. (Reread introduction if necessary.)

5. why the total of observed and expected offspring in Part A differ from the totals of observed and expected offspring in Part B.
6. (a) how the observed and expected offspring might have compared if only 16 coin tosses were used instead of 96.
(b) the need for using large numbers of observed offspring when attempting to prove that genetic totals of expected results do agree with observed results.
7. how Part B supports our understanding of genetics.
8. (a) the advantage of tossing and reading properly marked coins over using living organisms.
(b) whether the comparison between coins and living organisms is correct and why.

FIGURE 19-5

Extending Your Investigation

- Properly predict through the Punnett square in Figure 19-5 the expected phenotype combinations and number of each in a family with 16 offspring if one parent is *Aamm* and the other is *AAMm*.
- Properly mark four coins to agree with the parents' genotypes of *Aamm* and *AAMm*.
- Toss the four coins a total of 96 times, recording your observed results in Table 19-3.

Aamm X AAMm				
	Am	Am	am	am
AM				
Am				
AM				
Am				

TABLE 19-3. RESULTS OF CROSS BETWEEN *Aamm* and *AAMm*

PHENOTYPE COMBINATIONS	GENOTYPES	NUMBER EXPECTED FOR 16 OFFSPRING	NUMBER EXPECTED FOR 96 OFFSPRING	TOSS RESULTS	TOTAL NUMBER OBSERVED
Normal skin and normal height	<i>AAMm</i> <i>AaMm</i>				
Normal skin but midget	<i>AAMm</i> <i>Aamm</i>				
Albino but normal height	<i>aaMM</i> <i>aaMm</i>				
Albino and midget	<i>aamm</i>				

Analysis, Extension

1. Explain why the results in Table 19-3 are not the same as in Part A or B of this experiment.

PEDIGREE STUDIES

20

Pedigrees are not reserved for show dogs and race horses. All living things, including humans, have pedigrees. A pedigree is a diagram that shows the occurrence and appearance, or phenotype, of a particular genetic trait from one generation to the next in a family. Genotypes for individuals in a pedigree usually can be determined with an understanding of inheritance and probability.

In this investigation, you will

- (a) learn the meaning of all symbols and lines that are used in a pedigree.
- (b) calculate expected genotypes for all individuals shown in pedigrees.

Procedure

Part A. Background Information

The pedigree in Figure 20-1 shows the pattern of inheritance in a family for a specific trait. The trait being shown is earlobe shape. Geneticists recognize two general earlobe shapes, free lobes and attached lobes (Figure 20-2). The gene responsible for free lobes (*E*) is dominant over the gene for attached lobes (*e*).

In a pedigree, each generation is represented by a Roman numeral. Each person in a generation is numbered. Thus each person can be identified by a generation numeral and individual number. Males are represented by squares whereas females are represented by circles.

FIGURE 20-1

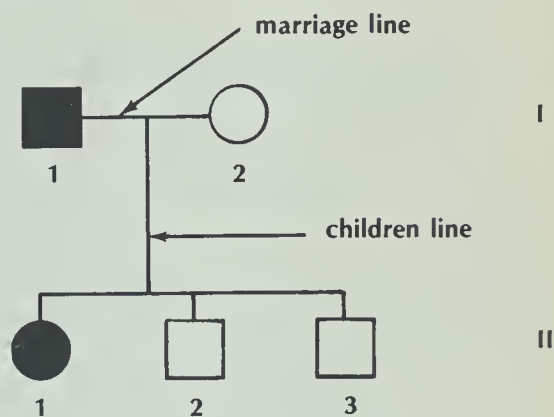
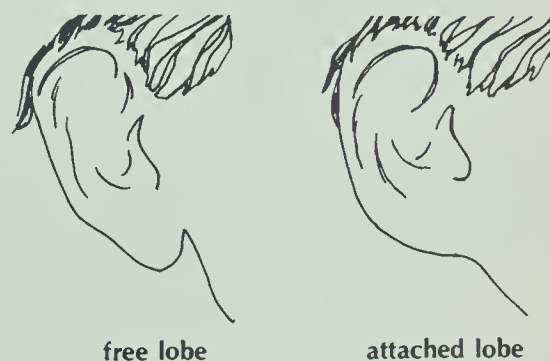


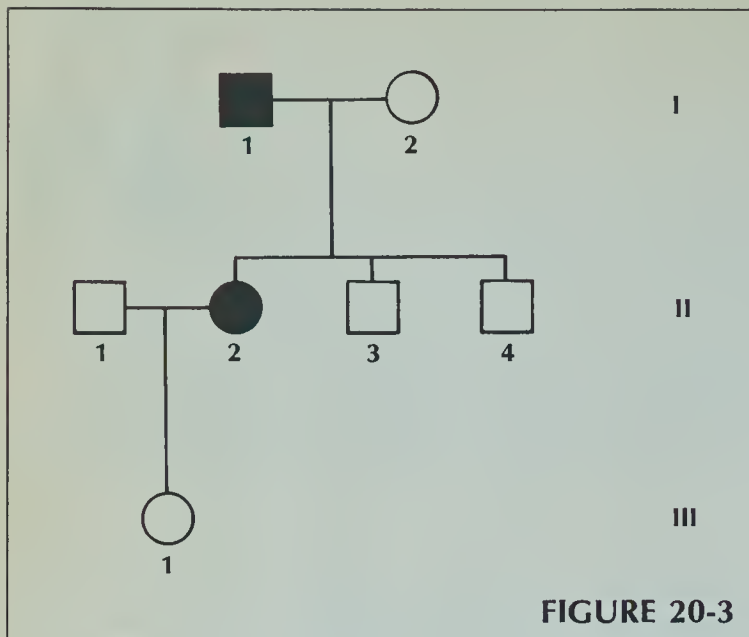
FIGURE 20-2



Part B. Reading a Pedigree

In Figure 20-1, persons I-1 and I-2 are the parents. The line which connects them is called a marriage line. Persons II-1, 2, and 3 are their children. The line which extends down from the marriage line is the children line. The children are placed left to right in order of their births. That is, the oldest child is always on the left.

1. What sex is the oldest child? _____
2. What sex is the youngest child? _____



Using a different pedigree of the same family at a later time shows three generations. Figure 20-3 shows a son-in-law as well as a grandchild. Generation I may now be called grandparents.

3. Which person is the son-in-law? _____
4. To whom is he married? _____
5. What sex is their child? _____

Part C. Determining Genotypes from a Pedigree

The value of a pedigree is that it can help predict the genes (genotype) of each person for a certain trait.

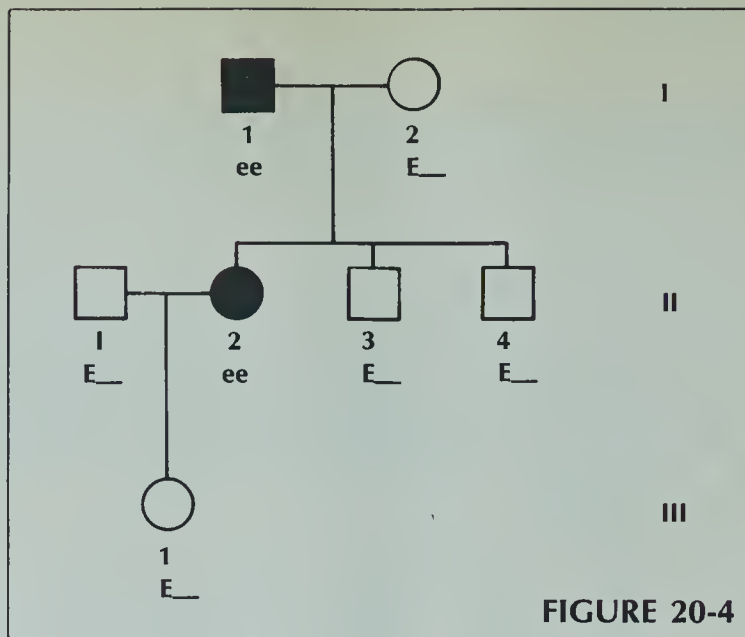
All shaded symbols on a pedigree represent individuals who are homozygous recessive for the trait being studied. Therefore, persons I-1 and II-2 have *ee* genotypes. They are the only two individuals who are homozygous recessive and show the recessive trait. They have attached earlobes.

All unshaded symbols represent individuals who have at least one dominant gene. These persons show the dominant trait.

To predict the genotypes for each person in a pedigree, there are two rules you must follow.

Rule 1. Assign two recessive genes to any person on a pedigree whose symbol is shaded. (These persons show the recessive trait being studied.) Small letters are written below the person's symbol.

Rule 2. Assign one dominant gene to any person on a pedigree whose symbol is unshaded. (These persons show the dominant trait being studied.) A capital letter is written below the person's symbol.



These two rules allow one to predict some of the genes for the persons in a pedigree. Figure 20-4 shows the genes predicted by using these two rules.

To determine the second gene for persons who show the dominant trait, a Punnett square is used. In Figure 20-4, we already know that the grandfather (I-1) is *ee*. If the grandmother (I-2) were *EE*, could any *ee* children (like II-2) be produced? A Punnett square shows this combination to be impossible. Thus, the grandmother must be heterozygous or *Ee*.

6. (a) Can an *Ee* parent and an *ee* parent have the results shown in generation II? _____
- (b) Prove your answer by showing the results in a Punnett square.

	e	e
E		
e		

7. (a) Predict the second gene for person II-3. (Read it from the Punnett square.) _____
- (b) Predict the second gene for person II-4. _____

(c) Could child II-3 or II-4 be EE ? _____

Explain. _____

To predict the second gene for person II-1, a different method must be used, since he could be either EE or Ee .

8. (a) Can an EE person married to an ee person (II-2) have children with free earlobes?

(b) Can an Ee person married to an ee person

have children with free earlobes? _____

(c) Prove your answers by showing the results of these crosses in the Punnett squares below.

	e	e		e	e
E			E		
E			e		

In this case, the second gene from person II-1 cannot be predicted using Punnett squares. Either genotype Ee or EE may be correct. When this situation occurs, both genotypes are written under the symbol (Figure 20-5).

Predicting the second gene for III-1 results in her being heterozygous. Although her mother must provide her with one recessive gene, she has free lobes, so the second gene must be dominant (Figure 20-5).

At some time in the future, if II-1 and II-2 have many more children, one might be able to predict the father's second gene. For example, if they have ten children and all show the dominant free lobes, one could safely conclude that he is EE . If, however, they have some children with attached earlobes (ee), then he must be Ee .

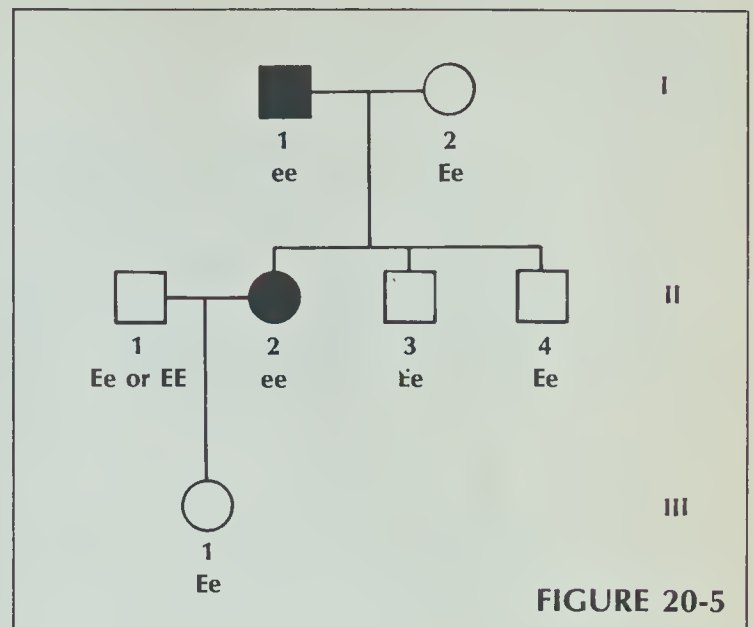
Analysis

1. Draw a pedigree for a family showing two parents and four children.

(a) include a marriage line and label it.

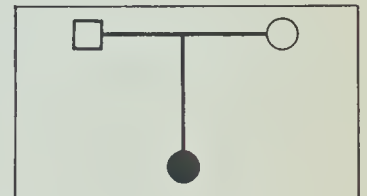
(b) include a children's line and label it.

(c) make the oldest two children boys and the youngest two girls.



When both parents show a dominant trait and their child or children all show a dominant trait, one cannot predict the second gene for anyone if only a small family is available.

Examine this pedigree:



9. (a) Which Punnett square, A, B, or C, would best fit this family? _____

	E	e		E	e
E			E		
E			e		

A

	E	E
E		
E		

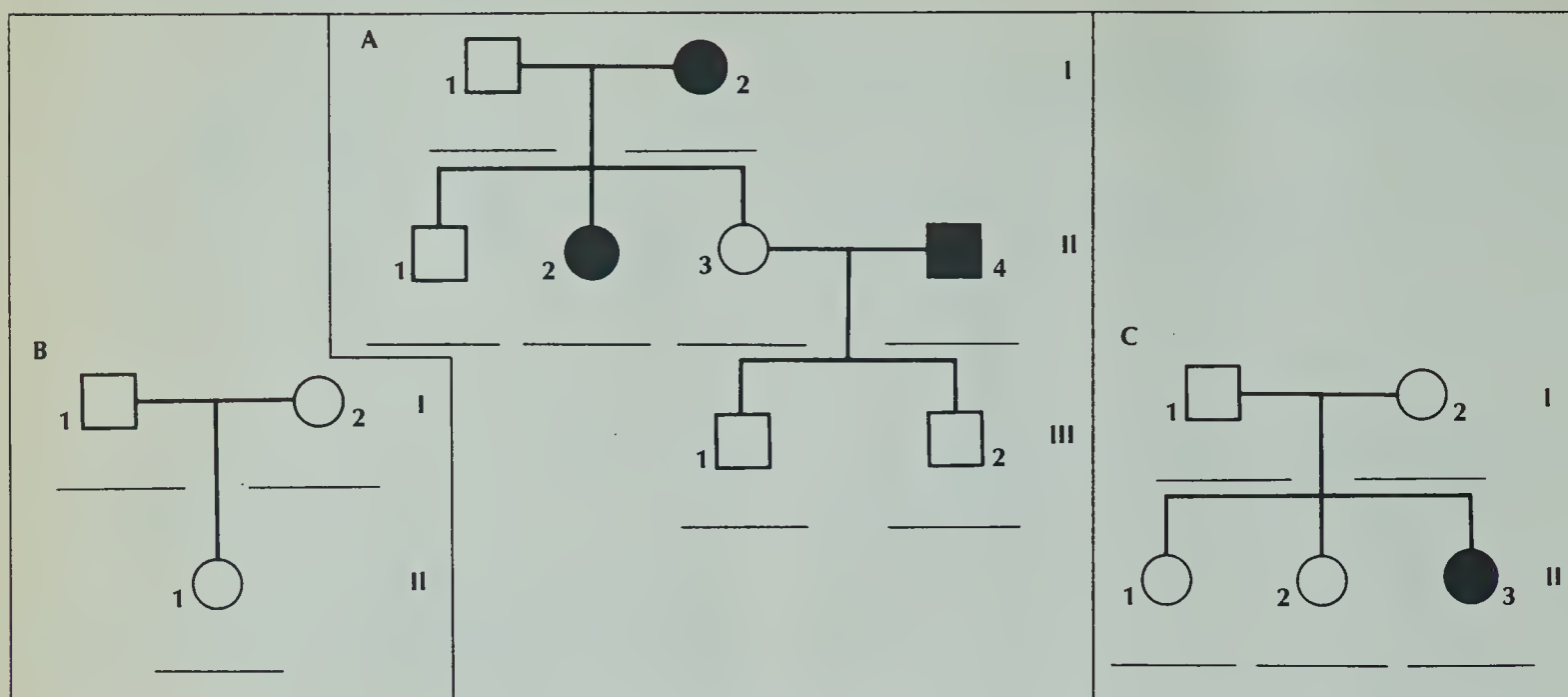
C

	E	e
E		
e		

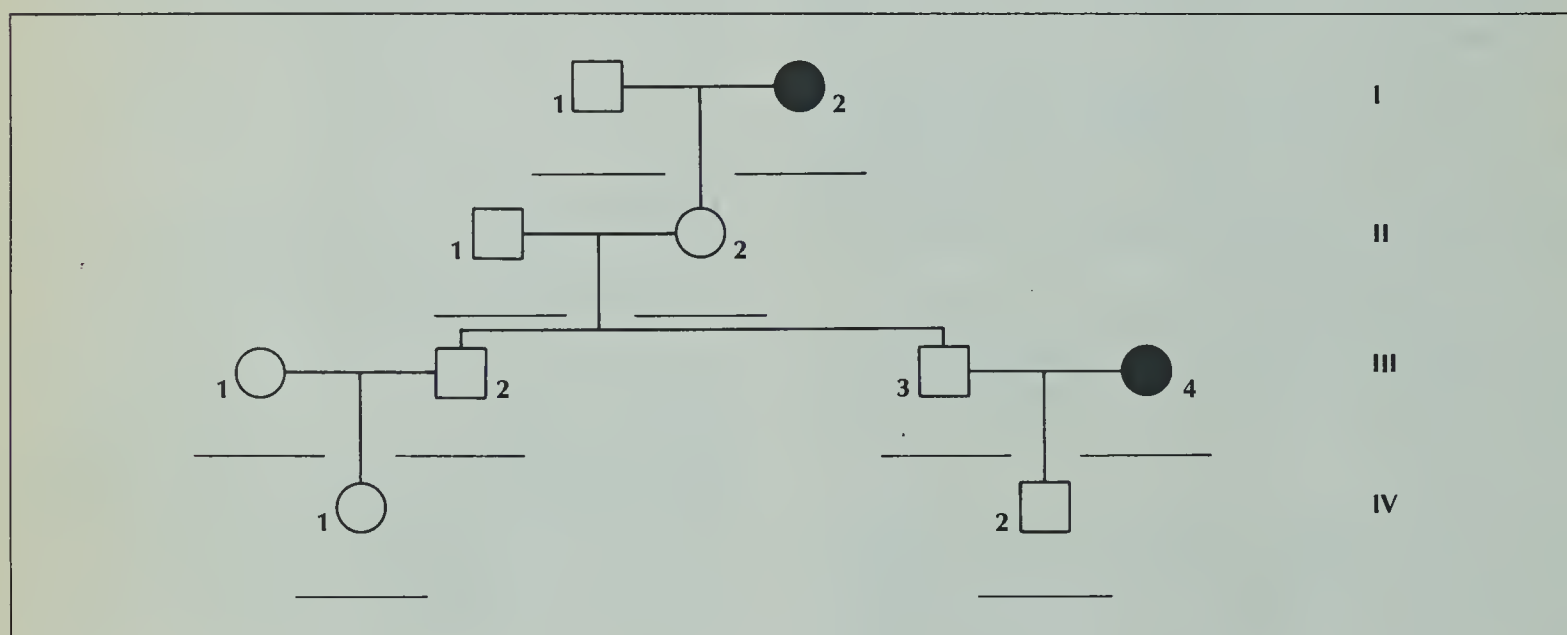
B

(b) Explain. _____

2. Using the pedigree from question 1, indicate that person II-2 has attached earlobes.
3. Using the pedigrees below, predict the genotypes for these families. (Remember the two rules—first give all shaded symbols two recessive genes and give unshaded symbols one dominant gene.) Write the letters on the lines provided.



4. Examine the pedigree below.



- (a) How many generations are shown? _____
- (b) How many persons have free earlobes? _____
- (c) How many persons have attached earlobes? _____
- (d) Identify by generation and number those persons with attached earlobes. _____
- (e) Give the genotype for all persons having attached earlobes. _____
- (f) How many children did the original generation have? _____

5. Predict the genotypes for all persons in question 4 using the lines below each person's symbol.

A CHROMOSOME STUDY

21

An examination of the chromosomes of a cell under high magnification can give much information about an organism. The page given to you by your teacher shows the chromosomes of a body (somatic) cell as they might appear in an organism if enlarged many times their natural size. Body cells are produced by a process called mitosis. This process forms new cells with the same chromosome number as the cell that divided.

In this investigation, you will

- learn what a chromosome karyotype is.
- prepare a karyotype of chromosomes according to the instructions provided.
- answer questions regarding the karyotype.
- determine major differences between somatic (body) and reproductive (egg and sperm) cells.

Materials

scissors tape
paper page of chromosomes

Procedure

Examine the page of chromosomes supplied to you by your teacher. These chromosomes are greatly enlarged. Cut out each chromosome with scissors. **CAUTION:** *Always be careful with scissors.* To make the task easier and faster, leave margins of paper along each chromosome. Cut them out as rectangles or squares as shown here:



- Prepare a karyotype of these chromosomes. A karyotype is a pattern of chromosomes grouped into pairs and then organized by size.

- To help determine pairs, use the location of the centromere. The centromere is the narrow place on the chromosomes where chromatids of a chromosome are joined.

- Match all chromosomes into pairs as best you can. Mount each pair onto a sheet of paper with tape. Position the longest pair on the upper left-hand corner of your paper. The next longest pair should follow until all pairs are taped to the paper in decreasing order of size.

- If unmatched chromosomes are left over, mount them in the lower right-hand corner of your paper.

1. How many chromosomes are present in the somatic cells of this organism? _____

The term "diploid chromosome number" or " $2n$ number" refers to the total number of chromosomes in any somatic cell of an organism. The diploid number varies from species to species. However, it does not differ from somatic cell to somatic cell of an organism.

2. What is the diploid chromosome number for this organism? _____
3. How many chromosomes are in liver cells of this organism? _____
4. What is the $2n$ chromosome number for skin cells of this organism? _____
5. How many chromosome pairs are present in the somatic cells of this organism? _____

6. How many unpaired chromosomes are present in the somatic cells of this organism? _____

The two remaining chromosomes (unpaired) are called sex chromosomes. Sex chromosomes determine the sex of the organism. The longer of the unpaired chromosomes is called the X chromosome. The shorter chromosome is called the Y chromosome.

Some organisms, including humans, have paired sex chromosomes. The XX combination produces a female. The XY combination produces a male. Humans have a $2n$ chromosome number of 46.

7. Which sex chromosomes are present in the karyotype that you prepared? _____

8. What is the sex of this organism? _____

9. What is the sex of a human if there are 23 matched pairs of identical sex chromosomes in all somatic cells? _____

10. Which sex chromosomes do you have? _____

Gametes or reproductive cells (sperm and egg cells) have only the n , or monoploid (haploid) chromosome number. Human egg or sperm cells have only 23 chromosomes. The monoploid, or n chromosome number, is always one half the diploid or $2n$ number.

11. The diploid chromosome number for a rabbit is 44. How many chromosomes are present in each rabbit sperm cell? _____

12. Corn has 10 chromosomes in each of its egg cells. What is the $2n$ number of corn? _____

Gametes differ from somatic cells in another way. Only one member of each chromosome pair is present. There are no chromosome pairs in gametes. This arrangement of chromosomes is the result of nuclear division called meiosis.

13. List two ways that gametes differ from somatic cells. _____

Analysis

Compare somatic cells and gametes by completing Table 21-1.

TABLE 21-1. COMPARISON OF SOMATIC CELLS AND GAMETES		
	SOMATIC CELLS	GAMETES
Name of nuclear division process responsible for formation (mitosis or meiosis)		
Chromosome number present (diploid or monoploid)		
$2n$ number present (yes or no)		
n number present (yes or no)		
Most or all chromosomes paired (yes or no)		
No matched chromosome pairs present (yes or no)		
Contains XX or XY chromosome along with remaining chromosomes (yes or no)		
Contains either an X or Y along with remaining chromosomes (yes or no)		

HEREDITY OR ENVIRONMENT?

22

Is heredity or environment more important in determining the kinds of traits that appear in offspring? This investigation will attempt to illustrate the importance of each by using corn seeds. In corn, the green gene (*G*) is dominant to the albino (white) gene (*g*). The seeds you will use are from parent plants that were both heterozygous. (*Gg*).

In this investigation, you will

- determine the expected number of normal to albino corn plants by using a Punnett square.
- prepare growth chambers and grow corn seeds in two different environments.
- examine the plants and record class totals of green and white plants.
- examine the plants and record class data after all plants are in sunlight several days.
- determine the influence of light on a genetic trait by comparing and analyzing class data.

Materials

corn seeds labels
petri dishes—2 paper towels
water

Procedure

Part A. Determining the Number and Percentage of Expected Albino Offspring

- By using the Punnett square in Figure 22-1, determine the possible genotypes of seeds produced by plants heterozygous for albinism (*Gg*).

- Out of four plants, how many are expected to be

(a) green? _____

(b) albino? _____

- Express the expected number of albino offspring as a percentage by using the following formula.

$$\frac{\text{Total albino plants}}{\text{Total plants}} \times 100 = \% \text{ albino plants}$$

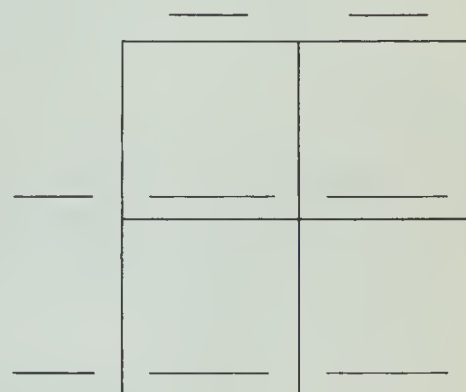
The percentage of expected albino plants is

_____.

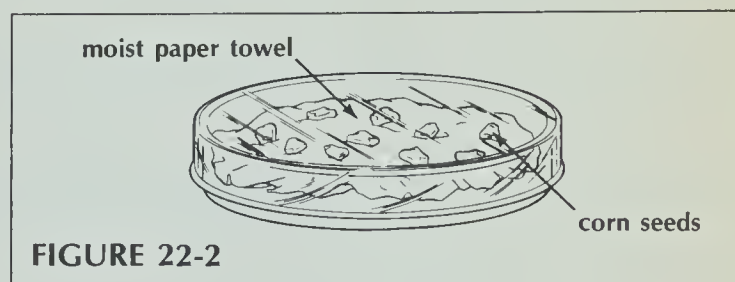
Part B. First Observation

- Place several thicknesses of paper towel in the bottom of two petri dishes. Moisten the paper with water.

FIGURE 22-1



- Add ten corn seeds to each petri dish.
- Spread the seeds apart so they are not touching each other (Figure 22-2).



- Cover each dish and label it with your name and the type of environment in which it is to be placed. One dish will be marked "DARK." The other will be marked "LIGHT."
- Place each dish in its proper environment.

- After several days, observe the plants that have grown from seeds in your petri dishes. Note how many in each dish are green or albino (white or yellow). Combine your results (totals) with those of your classmates to complete Table 22-1.

Part C. Second Observation

- After your first observation, place all petri dishes

in a light environment for several days. Moisten the paper if necessary.

- After several days, observe the plants. Note how many in each dish are green or albino (white or yellow).
- Combine your results (totals) with those of your classmates to complete Table 22-2.

TABLE 22-1. CLASS RESULTS OF FIRST OBSERVATION					
PLANTS IN DARK			PLANTS IN LIGHT		
Number of green	Number of albino	Percentage of albino	Number of green	Number of albino	Percentage of albino

TABLE 22-2. CLASS RESULTS OF SECOND OBSERVATION					
PLANTS IN DARK THEN IN LIGHT			PLANTS ALWAYS IN LIGHT		
Number of green	Number of albino	Percentage of albino	Number of green	Number of albino	Percentage of albino

Analysis

NOTE: Read these statements before answering any questions.

- Corn plants require two factors in order to produce chlorophyll. They must have the proper gene combination (at least one dominant *G* gene) and also be exposed to light.
- When doing any experiment, the more data or results you can gather, the more reliable your conclusions should be.

- Explain why the percentage of albino plants in the dark in the first observation did not agree with expected results obtained from the Punnett square. _____
- (a) What happened to the percentage of white plants when those in the dark were placed in the light for several days? _____
 (b) Does the percentage of albinos at this point agree or come close to the expected percentage of albinos in Part A? _____ Explain. _____
- (a) What happened to the percentage of albino plants when those in the light remained in the light for several more days? _____
 (b) Explain. _____
- Explain how it is possible for environment to influence or temporarily change the expression of a gene. _____

SEX-LINKED OR NOT SEX-LINKED?

23

An inherited form of muscular dystrophy results in death due to a wasting away of skeletal muscles. The dominant normal gene is represented by the letter M . The recessive gene is represented by m . How is the trait inherited? Is it a sex-linked genetic disease or not? If it is sex-linked, the gene is located on the X chromosomes. If it is not sex-linked, the gene is located on a chromosomal pair other than the sex chromosomes.

In this investigation, you will

- mark coins to represent genes and chromosomes in gamete cells of human males and females.
- toss two coins together to simulate the offspring observed if muscular dystrophy is sex-linked.
- toss four coins together to simulate the offspring observed if muscular dystrophy is not sex-linked.
- determine whether or not muscular dystrophy is sex-linked through the analysis of your data and statements supplied by a hospital.

Materials

adhesive tape
pennies—2
nickels—2
pencil

Procedure

Part A. Observed Results If Sex-Linked

If a trait is sex-linked, the genes are located on the X chromosome. A heterozygous female ($X^M X^m$) has a 50/50 chance that her egg cells will receive either an X^M or an X^m during meiosis. Normal males have genotype $X^M Y$. The chances that their sperm cells will receive either X^M or Y during meiosis are 50/50. You can determine the offspring of the cross $X^M X^m \times X^M Y$ by coin tossing.

- Put adhesive tape on two pennies.
- Mark one penny to represent the possible egg cells. Mark one side X^M and the other side X^m .
- Mark the second penny to represent the possible sperm cells. Mark one side X^M and the other side Y.

- Toss both pennies together 48 times. Use slashes (/) to indicate in Table 23-1 the combination that results after each toss.

- Total the results of each genotype and record them in the table.

Part B. Observed Results If Not Sex-Linked

If the trait is not sex-linked, the genes for muscular dystrophy are not attached to the sex chromosomes. Therefore, two pairs of chromosomes are involved in determining sex and the presence or absence of muscular dystrophy. In obtaining observed results by tossing coins, four coins are needed to represent the two chromosome pairs involved in the cross $XXMm \times XYMm$.

- Add tape to a penny and a nickel. NOTE: You may use the pennies from Part A, but they must be re-marked.
- Mark both sides of the penny with an X. Mark one side of the nickel M and the other side m. These coins represent possible gametes of a heterozygous female.
- Add tape to a second penny and nickel.
- Mark one side of the penny X and the other side Y. Mark one side of the nickel M and the other side m. These coins represent possible gametes of a heterozygous male.
- Toss the pennies and nickels together onto your desk 48 times. Use slash marks (/) to indicate in Table 23-2 the combination that results after each toss.
- Total the results of each genotype and record them in the table.

TABLE 23-1. RESULTS IF THE TRAIT IS SEX-LINKED			
OFFSPRING PHENOTYPE	OFFSPRING GENOTYPE	RESULT OF EACH TOSS	TOTALS OBSERVED
Normal female	$X^M X^M$ or $X^M X^m$		
Female with muscular dystrophy	$X^m X^m$		
Normal male	$X^M Y$		
Male with muscular dystrophy	$X^m Y$		

TABLE 23-2. RESULTS IF THE TRAIT IS NOT SEX-LINKED			
OFFSPRING PHENOTYPE	OFFSPRING GENOTYPE	RESULTS OF EACH TOSS	TOTALS OBSERVED
Normal female	$X^M X^M$ or $X^M X^m$		
Female with muscular dystrophy	$X^m X^m$		
Normal male	$X^M Y^M$ or $X^M Y^m$		
Male with muscular dystrophy	$X^m Y^m$		

Analysis

- (a) If a trait is sex-linked, how many genes for muscular dystrophy must a female inherit to have the disease? _____
- (b) If a trait is sex-linked, how many genes for muscular dystrophy must a male inherit to have the disease? _____

2. (a) If a trait is not sex-linked, how many genes for muscular dystrophy must a female inherit to have the disease? _____
- (b) If a trait is not sex-linked, how many genes for muscular dystrophy must a male inherit to have the disease? _____
3. (a) How many normal female children were observed when the trait was considered to be sex-linked, the mother heterozygous, and the father normal? _____
- (b) How many normal female children were observed when the trait was considered to be not sex-linked and both parents heterozygous (Mm)? _____
- (c) Are the observed results similar in both cases? _____
4. (a) How many diseased female children were observed when this trait was considered to be not sex-linked and both parents heterozygous (Mm)? _____
- (b) How many diseased female children were observed when the trait was considered to be sex-linked, the mother heterozygous, and the father normal? _____
- (c) Are the observed results similar in both cases? _____
5. Which inheritance pattern results in no diseased females? _____
6. According to studies from a leading hospital, no female child with muscular dystrophy has ever been reported from a family where the father is normal and the mother is normal but heterozygous. In view of this true statement, which set of your observed data tends to support this statement? (Is the trait probably sex-linked or not?) _____
7. (a) How many normal male children were observed when the trait was considered to be not sex-linked and both parents heterozygous. (Mm)? _____
- (b) How many diseased male children were observed when the trait was considered to be not sex-linked? _____
- (c) Are the observed results similar in both cases? _____
8. (a) How many normal male children were observed when the trait was considered to be sex-linked, the mother heterozygous, and the father normal? _____
- (b) How many diseased male children were observed when the trait was considered to be sex-linked? _____
- (c) Are the observed results similar in both cases? _____
9. Which inheritance pattern provides about equal numbers of normal and diseased male children? _____
10. According to studies from the same hospital as in question 6, male children with muscular dystrophy occur as often as normal male children in families where the fathers are normal and the mothers are heterozygous. In view of this true statement, which of your observed data tends to support this statement? (Is the trait probably sex-linked or not?) _____

11. A woman is color-blind. Her husband has normal color vision. (Color vision is dominant over color-blindness.) They have 12 children. All daughters have normal color vision while all sons are color-blind.
- (a) Do these offspring indicate that color-blindness is sex-linked or that it is not sex-linked?
- _____
- (b) Explain. _____
- _____
12. Hemophilia is a sex-linked disease. Blood clotting is greatly delayed or does not occur in a person with this condition. If you represent the gene for normal blood clotting with the letter *C* (dominant) and the gene for hemophilia with the letter *c* (recessive),
- (a) how would a coin be marked for a homozygous dominant (two dominant genes) female?
- (Remember, it is sex-linked.) _____
- (b) how would a coin be marked for a male with the disease? (HINT: How many genes does a male have for this trait?) _____
13. Mark two coins as suggested in question 12a and 12b. Flip your two coins together 48 times. Record all combinations that result by constructing a suitable data chart in the space provided. Total all combinations that are observed through coin flips and indicate these totals on your data chart.
14. On a separate paper, write a brief report explaining your recorded data in question 13. Include in the report:
- (a) the genotypes in the cross of the homozygous dominant mother and the hemophiliac father,
 - (b) the genotypes of possible eggs and sperms,
 - (c) the number of male hemophiliacs as compared to the normal males that result in the offspring,
 - (d) the number of female hemophiliacs as compared to the normal females that result in the offspring,
 - (e) the number of hemophiliac offspring as compared to normal offspring, and
 - (f) the number of heterozygous females as compared to homozygous females in the offspring.
15. Draw a pedigree in the space below showing the cross in 14a and the possible offspring. You may need to review Investigation 20 for information about the symbols to use.

DNA AND RNA

24

Deoxyribonucleic acid (DNA) is a complex molecule found in all living organisms. DNA is the chemical of which genes are composed. An understanding of the organization of this molecule has answered many questions. Scientists now know how chromosomes can duplicate during cell division and transfer their genetic information to new chromosomes. Scientists also understand how chromosomes in the cell nucleus can direct the formation of specific proteins outside the nucleus.

In this investigation, you will

- learn the names of the molecules which make up DNA.
- use models to construct a molecule of DNA and show how it replicates.
- learn the names of the molecules which make up RNA.
- use models to show how the base sequence code in DNA is transcribed exactly to RNA.

Materials

4 pages of paper models

scissors

NOTE: SAVE ALL MODEL PARTS. THEY WILL BE NEEDED FOR INVESTIGATION 25.

Procedure

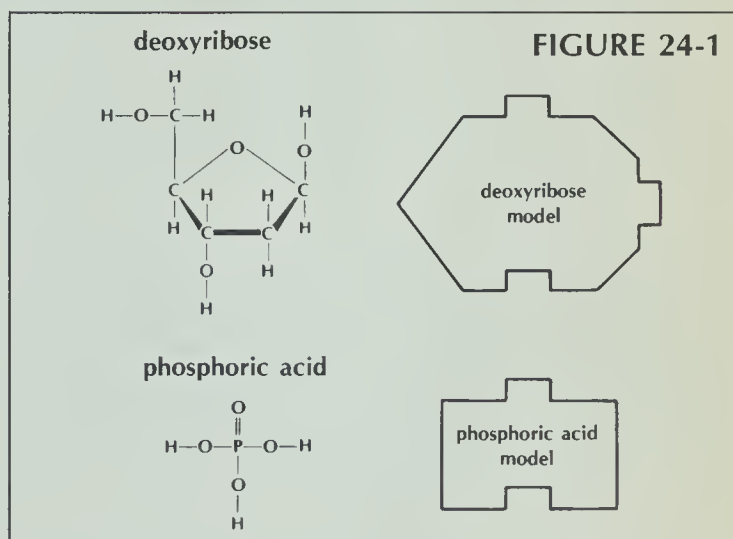
Part A. Structure of DNA Nucleotides

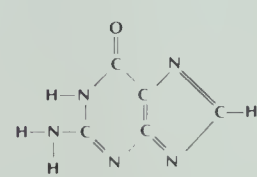
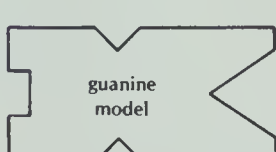
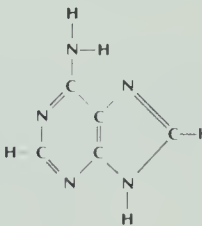

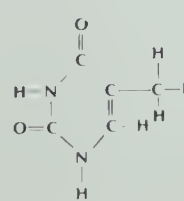
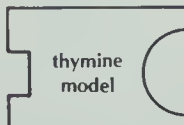
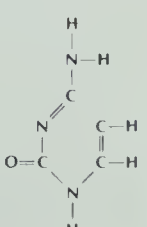
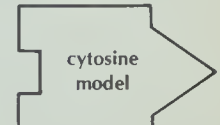
Two important molecules which make up DNA are deoxyribose and phosphoric acid. Their models and structural formulas are shown in Figure 24-1.

1. Give the molecular formula for

- deoxyribose C__H__O__
- phosphoric acid H__P__O__

Deoxyribose is a carbohydrate. Phosphoric acid was studied previously as a molecule in ATP.



<p>guanine</p>   <p>guanine model</p>	<p>adenine</p>   <p>adenine model</p>
<p>thymine</p>   <p>thymine model</p>	<p>cytosine</p>   <p>cytosine model</p>

In addition, there are four different molecules called bases. Their structural formulas and models are shown on page 93.

2. Of the four bases, which other base does

(a) adenine most resemble in shape? _____

(b) thymine most resemble in shape? _____

A molecule of deoxyribose joins with phosphoric acid and any one of the four bases to form a chemical compound called a nucleotide. A nucleotide is named for the base that joins with the deoxyribose. For example, if thymine attaches to deoxyribose, the molecule is called a thymine nucleotide.

• Use the pages of nucleotide models to answer questions 3 and 4.

3. List the four different nucleotides. _____

4. (a) How is each nucleotide alike? _____

(b) How does each nucleotide differ? _____

Part B. Structure of a DNA Molecule

A DNA molecule is "ladderlike" in shape. Deoxyribose and phosphoric acid molecules join to form the sides or uprights of the ladder. Base molecules join to form the rungs of the ladder.

• Cut out the 24 nucleotide models provided by your teacher. *Cut only on solid lines.* **CAUTION:** *Always be careful when using scissors.*

• Fit six nucleotides together in puzzlelike fashion to form a row in the following sequence from top to bottom:

Cytosine nucleotide
Thymine nucleotide
Guanine nucleotide
Adenine nucleotide
Guanine nucleotide
Cytosine nucleotide

Let this arrangement represent the left half of a ladder molecule. It should consist of one side or upright plus six half rungs.

5. If DNA is "ladderlike," which two molecules of a nucleotide form the sides, or upright portion of the ladder? _____

6. To which molecule does each base attach? _____

7. Name the molecules of each nucleotide that form part of the ladder's rungs. _____

• Complete the right side of the DNA ladder by matching the bases of other nucleotides to form complete rungs. It may be necessary to turn molecules upside down in order to join certain base combinations. **NOTE:** The ends of each base will allow only a specifically shaped matching new base to fit exactly.

Your completed model should look like a ladder with matched bases as the rungs. Besides being shaped like a ladder, a DNA molecule is twisted. It looks like a spiral staircase. However, your paper model cannot show this shape.

8. Is the order of half-rung bases exactly the same from top to bottom of each side of your model? _____

9. Only two combinations of base pairings are possible for the rungs. Name these molecule combinations or pairs. _____

10. If four guanine bases appear in a DNA model, how many cytosine bases should there be? _____

11. Your DNA model has four guanine bases.
(a) Does the number of cytosine bases in your

model agree with your prediction? _____

(b) The following are the bases on the left side of a DNA molecule. List the bases that would make up the right side of a DNA molecule.

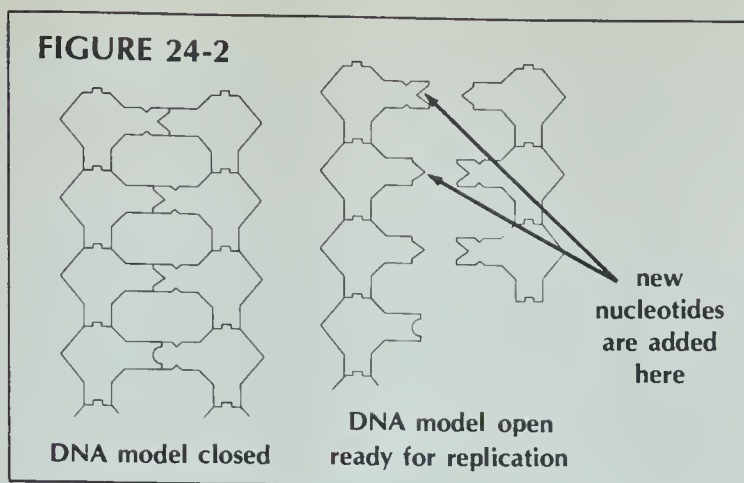
Thymine _____

Adenine _____

Guanine _____

Guanine _____

Cytosine _____



Part C. DNA Replication

A chromosome contains DNA. Your DNA model represents only a short length of the DNA portion of a chromosome. An entire chromosome has thousands of rungs rather than only six. Although your model is only a small part of a chromosome, its replication is the same as that of an entire chromosome during mitosis and meiosis.

- Open your DNA model along the point of attachment between base pairs (rungs) and separate the two ladder halves. (A chromosome untwists and “unzips” in a similar way prior to replication.) See Figure 24-2 as a guide.
- Using the left half of your model as a pattern, add new nucleotides to form a new right side.
- Build a second DNA model by adding new nucleotides to the right half of the original model.

12. Do the two new molecules contain the same number of rungs? _____

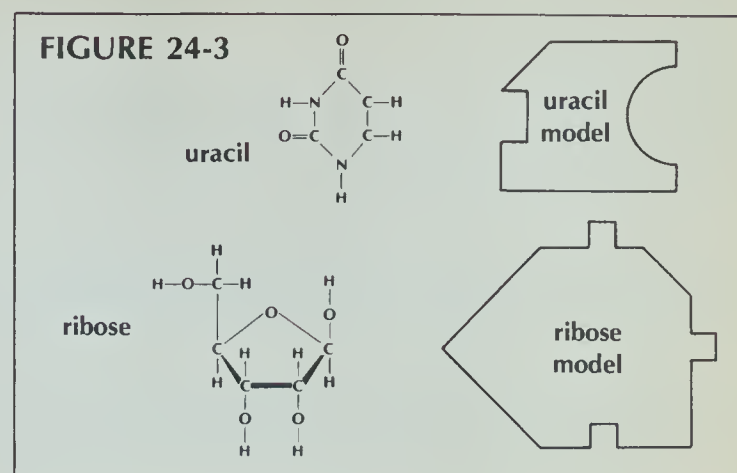
13. Is the order from top to bottom of base pairs (rungs) different or the same for each new DNA molecule? _____

14. How many molecules of adenine and thymine are in each DNA molecule? _____

15. Do the numbers agree? _____

16. Are the two DNA molecules exact copies of each other? _____

The specific order of bases in DNA serves as a code or language. When a chromosome replicates, the code (the order in which the bases occur) is carried over to the new chromosome.



17. What is the code of a chromosome? _____

Part D. RNA Structure

Besides ensuring the exact replication of chromosomes, the sequence (order) and pairings of bases are a genetic code of the instructions for the entire cell. How does a cell “read” the chemical message coded in its DNA in the form of specific base sequences? Part of the answer lies with a second molecule in the nucleus of cells called ribonucleic acid (RNA).

RNA is similar to DNA in that its molecules are also formed from nucleotides. However, deoxyribose and thymine are not found in RNA. Two other molecules, ribose and uracil, are present. Ribose replaces deoxyribose, and uracil replaces thymine. Looking at their structural formulas and models, you will see certain similarities between the molecules that they replace. Formulas and models are shown in Figure 24-3.

18. (a) Which base is replaced in RNA by uracil? _____

(b) What chemical replaces deoxyribose in RNA? _____

19. To which base in DNA do the following RNA bases pair?

(a) guanine _____

(b) adenine _____

(c) cytosine _____

(d) uracil _____

Part E. RNA Transcription

● Cut out the six RNA nucleotide models. *Cut only along solid lines.*

● Open or unzip one of the DNA chromosomes along the base pair points of attachment and separate the two halves.

● Using the left side of your DNA model as a pattern, match RNA nucleotides with the proper nucleotides of the DNA half.

20. Do the RNA half-rung bases pair exactly as they would if this were DNA replication?

● Remove the RNA nucleotide series from the DNA pattern.

● Close the DNA molecule back up with its original right side. (DNA molecules "unzip" temporarily during RNA production.)

RNA is a single-stranded (or $\frac{1}{2}$ ladder) molecule. Thus, the series of RNA nucleotides formed from DNA represents an RNA molecule. After its formation, this RNA leaves the nucleus of the cell and goes to the ribosomes. It carries the DNA message of base sequences in the exact same order. Therefore, the formation of this series of RNA nucleotides is called transcription.

Analysis

1. Complete Table 24-1 by using check marks to indicate to which molecule each characteristic applies.

TABLE 24-1. SIMILARITIES AND DIFFERENCES BETWEEN DNA AND RNA		
	DNA	RNA
Deoxyribonucleic acid		
Ribonucleic acid		
Ribose present		
Deoxyribose present		
Phosphoric acid present		
Adenine present		
Thymine present		
Uracil present		
Guanine present		
Cytosine present		
Formed from nucleotides		
Double stranded		
Single stranded		
Remains in nucleus		
Moves out of nucleus		
Contains a chemical message or code		

tRNA AND PROTEIN BUILDING

25

RNA produced in the nucleus of a cell moves out of the nucleus to the cell's ribosomes. This RNA is a specific sequence of bases copied from the DNA which carries the chromosomal genetic message to the cytoplasm. Thus, it is called messenger RNA (mRNA). At the ribosomes, mRNA directs the building of proteins. Proteins are made up of smaller molecules called amino acids. How does a cell construct the proper amino acids into protein molecules? Formation of proteins involves another kind of RNA. Transfer RNA (tRNA) brings specific amino acids to mRNA according to the code sequence of bases found on mRNA.

In this investigation, you will

- use paper models to show how base shapes in mRNA match only with specific base shapes of tRNA.
- use paper models to show how tRNA molecules bring specific amino acid molecules to the ribosome where building of proteins occurs.
- learn to transcribe a DNA code to a mRNA message and translate the mRNA to the tRNA—amino acid code.
- study the molecular basis for gene mutations.

Materials

models of RNA nucleotides from Investigation 24
scissors
page of paper models of tRNA

Procedure

Part A. Structure of tRNA

● Build a molecule of mRNA using the paper molecules from Investigation 24. Make sure you are using only RNA nucleotides. Join the RNA nucleotides to form a row of molecules in this order:

Guanine	Uracil
Adenine	Cytosine
Cytosine	Guanine

● Recall that molecules of mRNA leave the cell nucleus and move out to the cell's ribosomes. Meanwhile, transfer RNA (tRNA) is present in the cell cytoplasm. Models of tRNA were supplied to you by your teacher. Molecules of tRNA are composed of many base nucleotides. However, tRNA has a three base sequence (a triplet) that can match up with the bases of mRNA.

● Cut out the two models of tRNA. *Cut only along solid lines.* **CAUTION:** Always be careful with scissors.

- (a) Name the four nucleotide bases present in tRNA. _____

- (b) Do these bases differ from those found in mRNA? _____

- (c) How does the tRNA molecule differ from mRNA in shape? _____

● Join the tRNA molecules to the model of mRNA.

2. What base in mRNA can only join with the

- (a) adenine base of tRNA? _____

- (b) uracil base of tRNA? _____

- (c) guanine base of tRNA? _____

3. What order of bases on mRNA will match a sequence on tRNA of

(a) UUA? (uracil, uracil, adenine) _____

(b) UCA? (uracil, cytosine, adenine) _____

(c) UGA? (uracil, guanine, adenine) _____

(d) AAA? (adenine, adenine, adenine) _____

Transfer RNA picks up amino acids in a series of chemical steps. A tRNA molecule only picks up a certain amino acid. The amino acid is attached to the tRNA at the end opposite the three bases that will attach to mRNA.

● Cut out the two remaining models of amino acids, serine and aspartic acid, from the page provided by your teacher. Join these models to their proper tRNA models. Only a specific amino acid will fit along the top of each tRNA model. Remember that each tRNA model has a three sequence base called a triplet.

4. What amino acid connects to a tRNA molecule with a triplet of

(a) AGC? _____

(b) CUU? _____

5. What molecule receives the amino acids on tRNA? _____

6. How many base molecules or nucleotides of mRNA are responsible for the coding of one amino acid? _____

Part B. Forming a Protein Molecule During Translation

When many amino acid molecules are brought to the mRNA by tRNA, the amino acids join to form a protein molecule. When tRNA molecules with their attached amino acids join to the bases of the mRNA, the formation of a protein molecule is begun. This entire process is called translation. The DNA message has been translated into a protein molecule.

7. What amino acid is attached to a tRNA molecule having a base sequence of

(a) UUU? (Read from Table 25-1.) _____

(b) GCU? _____

8. What tRNA triplet is needed to join with the following amino acids:

(a) phenylalanine? (Read from Table 25-1.) _____

(b) valine? _____

(c) glutamic acid? _____

Depending on the type and order of amino acids, an almost endless variety of proteins can be produced. Because of the repeated matching of base sequences, the base sequence in the DNA of chromosomes codes for and controls the formation of protein molecules at ribosomes.

9. A protein molecule consists of the following amino acid sequence: leucine, glutamine, tyrosine, leucine, serine, serine. What would be the sequence of tRNA bases responsible for

forming this protein? (Use Table 25-1.) _____

10. A ribosome receives the following mRNA message: AAA, CGA, GAA, GUU.

(a) What will be the sequence of tRNA bases joining the mRNA molecule? _____

(b) What will be the sequence of amino acids formed from this code? _____

TABLE 25-1. tRNA TRIPLET CODES OF SOME AMINO ACIDS

AMINO ACID	tRNA CODE
Serine	AGC
Proline	GGG
Leucine	AAU
Glutamic acid	CUU
Tyrosine	AUA
Arginine	GCU
Glutamine	GUU
Phenylalanine	AAA
Valine	CAA
Lysine	UUU

As a review, you should now be able to transcribe (decode) a message in DNA base code into mRNA and then translate it into a protein molecule.

A portion of DNA on a chromosome has the sequence of bases along one strand of DNA as indicated in Table 25-2.

- Transcribe or decode this message first into mRNA code, then translate it into tRNA code and proper amino acids using Table 25-1.

TABLE 25-2. TRANSCRIBING AND TRANSLATING OF A DNA SEQUENCE

CHROMOSOME DNA CODE OF BASES	mRNA BASE CODE	tRNA BASE CODE	AMINO ACID SEQUENCE
AAT			
GGG			
ATA			
AAA			
GTT			

- Rework the cell's code language backward by completing Table 25-3.

TABLE 25-3. TRANSCRIBING AND TRANSLATING OF AN AMINO ACID SEQUENCE

AMINO ACID SEQUENCE	tRNA BASE CODE	mRNA BASE CODE	DNA BASE CODE
Proline			
Glutamic acid			
Lysine			
Serine			
Leucine			

Part C. Mutations and Base Sequence Errors

Not often are there errors in the process of forming proteins from the DNA code of instructions. An error in the process is a mutation and will result in formation of a different type of protein.

Hemoglobin is a protein in red blood cells. Hemoglobin results from the proper arrangement of almost 600 amino acids. Most humans have the correct type of hemoglobin. However, in some people the arrangement is incorrect. These people have a disease called sickle-cell anemia. Their red blood cells are sickle-shaped rather than round. As a result, the red blood cells cannot transport oxygen as well.

The following amino acid sequence represents a portion of the normal hemoglobin molecule: proline, glutamic acid, glutamic acid, lysine.

11. Translate the sequence of amino acids in normal hemoglobin into

(a) tRNA base codes. _____

(b) mRNA base codes. _____

(c) DNA base codes. _____

In sickle-cell anemia, the sequence of amino acids is slightly different. It is proline, valine, glutamic acid, lysine.

12. Translate the sequence of amino acids in sickle-cell hemoglobin into

(a) tRNA base codes. _____

(b) mRNA base codes. _____

(c) DNA base codes. _____

13. In terms of base nucleotides, explain the only difference between the DNA message for normal hemoglobin and the DNA message for sickle-cell hemoglobin. _____

A mutation, therefore, is a difference from what we consider to be the normal sequence of bases in a molecule of DNA. The difference or error does not have to be very great. As you have just determined, a base sequence of only one triplet (three bases) can cause the formation of the wrong type of hemoglobin. A change at only one base site of the triplet can cause mutation.

14. How are mutations passed on to offspring?

Analysis

1. What is the function of mRNA?
-
2. What is the function of tRNA?
-
3. How do tRNA and mRNA differ in their location within the cell?
-
4. (a) Briefly describe what is meant by translation.
-
-
- (b) What is being translated?
-
5. Complete this chart by using check marks to indicate to which molecule each characteristic applies.

SIMILARITIES AND DIFFERENCES BETWEEN mRNA AND tRNA		
	mRNA	tRNA
deoxyribose present		
ribose present		
phosphoric acid present		
adenine present		
thymine present		
uracil present		
guanine present		
cytosine present		
contains a chemical message or code		
carries an amino acid to a ribosome		

BIOCHEMICAL EVIDENCE FOR EVOLUTION

26

If two organisms have similar DNA molecules, they have similar proteins. Similar proteins have similar amino acid sequences (orders). Thus, if amino acid sequences are similar, DNA of the organisms is similar.

Scientists believe that similar DNA sequences indicate a common origin. The more similar the DNA of two living organisms, the more closely related they may be to one another.

Hemoglobin, a protein in red blood cells, has been studied. Scientists know the specific amino acids and their arrangements in hemoglobin molecules of humans, gorillas, and horses.

In this investigation, you will

- count and record differences in the sequence of amino acids in similar portions of human, gorilla, and horse hemoglobin.
- count and record the molecules of each amino acid present in similar portions of human, gorilla, and horse hemoglobin.
- use these data to show how biochemical evidence can be used to support evolution.

Procedure

Part A. Amino Acid Sequence

Figure 26-1 on page 102 represents the amino acid sequence of corresponding portions of the hemoglobin molecules of horses, gorillas, and humans.

- Read the amino acid sequences from left to right beginning at the upper left-hand corner of Figure 26-2. Compare the sequences of humans to the sequences of gorillas and horses. An example of a sequence difference between humans and gorillas is shown in Figure 26-1.

- Record in Table 26-1 the total number of differences in the sequences of gorilla and human amino acids. Then repeat this procedure for horse and human, and for gorilla and horse.

TABLE 26-1. NUMBER OF AMINO ACID SEQUENCE DIFFERENCES	
ORGANISMS	NUMBER OF DIFFERENCES
Gorilla and human	
Horse and human	
Gorilla and horse	

Part B. Numbers of Amino Acids

- Count the number of each kind of amino acid in human hemoglobin. Record the totals in the proper column of Table 26-2.

- Count each amino acid in the hemoglobin of gorillas and horses. Record these in Table 26-2.

Human:	Val	His	Pro	} This is a sequence difference between human and gorilla.
Gorilla:	Val	His	Gly	
Horse:	Val	His	Pro	

} This is a sequence difference between gorilla and horse.

This is not a sequence difference between human and horse.

FIGURE 26-1

FIGURE 26-2

Human:	Val	His	Leu	Thr	Pro	Glu	Glu	Lys	Ser	Ala	Val	Thr	Ala	Leu	Try
Gorilla:	Val	His	Leu	Thr	Pro	Glu	Glu	Lys	Ser	Ala	Val	Thr	Ala	Leu	Try
Horse:	Val	Glu	Leu	Ser	Gly	Glu	Glu	Lys	Ala	Ala	Val	Leu	Ala	Leu	Try
Human:	Gly	Lys	Val	Asp	Val	Asp	Glu	Val	Gly	Gly	Glu	Ala	Leu	Gly	Arg
Gorilla:	Gly	Lys	Val	Asp	Val	Asp	Glu	Val	Gly	Gly	Glu	Ala	Leu	Gly	Arg
Horse:	Asp	Lys	Val	Asp	Glu	Glu	Glu	Val	Gly	Gly	Glu	Ala	Leu	Gly	Arg
Human:	Leu	Leu	Val	Val	Tyr	Pro	Try	Thr	Glu	Arg	Phe	Phe	Glu	Ser	Phe
Gorilla:	Leu	Leu	Val	Val	Tyr	Pro	Try	Thr	Glu	Arg	Phe	Phe	Glu	Ser	Phe
Horse:	Leu	Leu	Val	Val	Tyr	Pro	Try	Thr	Glu	Arg	Phe	Phe	Asp	Ser	Phe
Human:	Gly	Asp	Leu	Ser	Thr	Pro	Asp	Ala	Val	Met	Gly	Asp	Pro	Lys	Val
Gorilla:	Gly	Asp	Leu	Ser	Thr	Pro	Asp	Ala	Val	Met	Gly	Asp	Pro	Lys	Val
Horse:	Gly	Asp	Leu	Ser	Asp	Pro	Gly	Ala	Val	Met	Gly	Asp	Pro	Lys	Val
Human:	Lys	Ala	His	Gly	Lys	Lys	Val	Leu	Gly	Ala	Phe	Ser	Asp	Gly	Leu
Gorilla:	Lys	Ala	His	Gly	Lys	Lys	Val	Leu	Gly	Ala	Phe	Ser	Asp	Gly	Leu
Horse:	Lys	Ala	His	Gly	Lys	Lys	Val	Leu	His	Ser	Phe	Gly	Glu	Gly	Val
Human:	Ala	His	Leu	Asp	Asp	Leu	Lys	Gly	Thr	Phe	Ala	Thr	Leu	Ser	Glu
Gorilla:	Ala	His	Leu	Asp	Asp	Leu	Lys	Gly	Thr	Phe	Ala	Thr	Leu	Ser	Glu
Horse:	His	His	Leu	Asp	Asp	Leu	Lys	Gly	Thr	Phe	Ala	Ala	Leu	Ser	Glu
Human:	Leu	His	Cys	Asp	Lys	Leu	His	Val	Asp	Pro	Glu	Asp	Phe	Arg	Leu
Gorilla:	Leu	His	Cys	Asp	Lys	Leu	His	Val	Asp	Pro	Glu	Asp	Phe	Leu	Leu
Horse:	Leu	His	Cys	Asp	Lys	Leu	His	Val	Asp	Pro	Glu	Asp	Phe	Arg	Leu
Human:	Leu	Gly	Asp	Val	Leu	Val	Cys	Val	Leu	Ala	His	His	Phe	Gly	Lys
Gorilla:	Leu	Gly	Asp	Val	Leu	Val	Cys	Val	Leu	Ala	His	His	Phe	Gly	Lys
Horse:	Leu	Gly	Asp	Val	Leu	Ala	Leu	Val	Val	Ala	Arg	His	Phe	Gly	Lys
Human:	Glu	Phe	Thr	Pro	Pro	Val	Glu	Ala	Ala	Tyr	Glu	Lys	Val	Val	Ala
Gorilla:	Glu	Phe	Thr	Pro	Pro	Val	Glu	Ala	Ala	Tyr	Glu	Lys	Val	Val	Ala
Horse:	Asp	Phe	Thr	Pro	Glu	Leu	Glu	Ala	Ser	Tyr	Glu	Lys	Val	Val	Ala
Human:	Gly	Val	Ala	Asp	Ala	Leu	Ala	His	Lys	Tyr	His				
Gorilla:	Gly	Val	Ala	Asp	Ala	Leu	Ala	His	Lys	Tyr	His				
Horse:	Gly	Val	Ala	Asp	Ala	Leu	Ala	His	Lys	Tyr	His				

TABLE 26-2. NUMBER OF EACH AMINO ACID

AMINO ACID	ABBREVIATION	HUMAN	GORILLA	HORSE
Alanine	Ala			
Arginine	Arg			
Aspartic acid	Asp			
Cysteine	Cys			
Glutamic acid	Glu			
Glycine	Gly			
Histidine	His			
Leucine	Leu			
Lysine	Lys			
Methionine	Met			
Phenylalanine	Phe			
Proline	Pro			
Serine	Ser			
Threonine	Thr			
Tryptophan	Try			
Tyrosine	Tyr			
Valine	Val			

Analysis

- Where is hemoglobin normally found? _____
- Circle those words which correctly apply to or describe hemoglobin: protein, carbohydrate, composed of amino acids, chemical molecule, composed of DNA.
- How many different kinds of amino acids are present in these three animals' hemoglobin? ____
- Which amino acid is most common in all three animals? _____
 - Which amino acid is next most common in all three animals? _____
 - Which amino acid is the least common in all three animals? _____

5. Use your data from Table 26-1 to answer these questions.
- (a) How similar are the amino acid sequences of human and gorilla hemoglobin? _____
 - (b) How similar are human and horse hemoglobin? _____
 - (c) How similar are gorilla and horse hemoglobin? _____
6. Of the different types of amino acids found in hemoglobin,
- (a) how many are present in the same exact number in humans and gorillas? _____
 - (b) in humans and horses? _____
 - (c) in gorillas and horses? _____
7. On the basis of your answer to question 6,
- (a) how similar are the chemical makeups of human and gorilla hemoglobin? _____
 - (b) how similar are human and horse hemoglobin? _____
 - (c) how similar are gorilla and horse hemoglobin? _____
8. Which two animals seem to have more similar hemoglobin? _____
9. The sequence of amino acids corresponds to the sequence of base molecules in DNA. Are the base sequences of DNA most similar in human and gorilla, gorilla and horse, or human and horse?

10. In numbers, explain how the base sequences (genes) for hemoglobin formation on human chromosomes differ from those in gorillas. (How many bases are different?) _____
11. What genetic mechanism may have been responsible for this base sequence change? _____

12. Give reasons for supporting or rejecting the following statement. Upon examination, segments of human and gorilla DNA responsible for inheritance of hemoglobin should appear almost chemically alike. _____

13. Give reasons for supporting or rejecting the following statement. Evolutionary relationships are stronger between living organisms which have close biochemical (protein) similarities than between living organisms which do not have close biochemical similarities. _____

A HUMAN VARIATION WITH POSSIBLE ADAPTIVE VALUE

27

Assume that suddenly, for some unknown reason, our only food source is starch. Those people that can digest starch (those best adapted to this new environmental condition) have better survival chances.

An enzyme present in human saliva, salivary amylase, begins starch digestion in the mouth. If some humans have more salivary amylase in their saliva, they would be better suited to this new environment than humans having little salivary amylase. Do humans have variation in the amount of amylase? Would this variation become an advantage for persons having more amylase if diets were restricted to starch?

In this investigation, you will

- use the iodine test to indicate the change of starch to sugar.
- determine how long it takes for a given amount of your salivary amylase to chemically change starch into sugar.
- determine if all students have similar amounts of salivary amylase.
- determine if there is variation of a genetic trait in a population (your class), and determine if this variation has possible adaptive value.

Materials

test tube stopper
test tubes—16
iodine solution
graduated cylinder

water
test tube rack
beaker
clock or watch with second hand

dropper
starch solution

Procedure

● Refer to Figure 27-1 as a guide as you complete the following steps.

● *Step 1.* Place 15 test tubes into a test tube rack. Add 30 drops of iodine to each tube. Set tubes aside. **CAUTION:** *Iodine is poison. If spillage occurs, wash with water and call your teacher immediately.*

● *Step 2.* Prepare a 6% saliva solution. Add enough of your saliva to just cover the bottom of a clean test tube. Add 100 mL of water and stopper the tube. Place thumb over stopper and shake.

● *Step 3.* Prepare a mixture of starch and 6% saliva. Add 7 mL of starch to a beaker. Add 20 drops of the 6% saliva solution from the test tube. Stir the

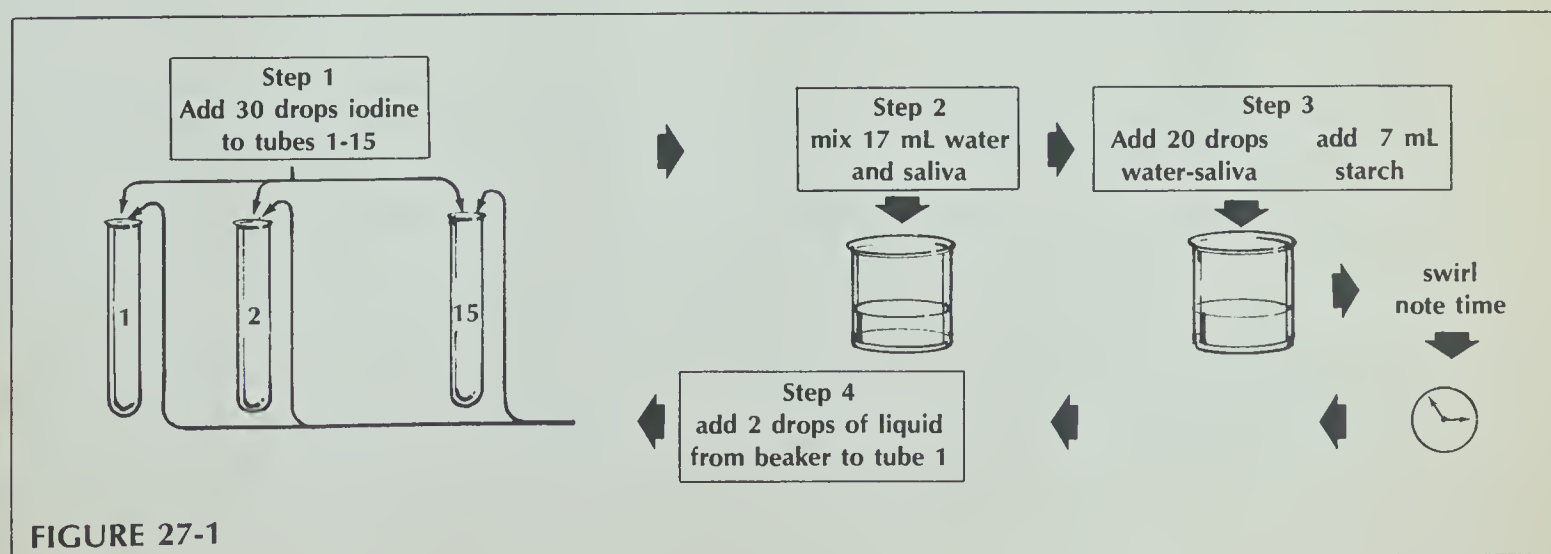


FIGURE 27-1

mixture with the dropper. Note the exact time you mixed the starch and saliva solutions.

● *Step 4.* After 2 minutes, add two drops of the liquid in the beaker to the first tube containing iodine. Discard any liquid remaining in the dropper.

● Record in Table 27-1 the color change (if any) in the iodine solution. Use the following colors only: dark blue, light blue, rust (iodine) color.

● After two minutes, add two drops of liquid from the beaker to the next test tube of iodine solution. Record the color in Table 27-1. Use only one test tube for each two minute interval.

● Continue adding liquid from the beaker and recording the color at two-minute intervals until all test tubes of iodine solution have been used or until the blue color is no longer present in the iodine test tubes.

NOTE: The presence of a blue color in the iodine solution indicates starch is present. The saliva has not yet changed the starch. No blue color in the iodine solution means that the saliva has changed the starch to sugar.

● Use Table 27-1 to record class totals. Record the total number of students (if any) who completed starch change within each of the two-minute intervals.

TABLE 27-1. INDIVIDUAL RESULTS	
TWO-MINUTE INTERVALS	COLOR OF IODINE SOLUTION
0	blue-black
2	
4	
6	
8	
10	
12	
14	
16	
18	
20	
22	
24	
26	
28	
30	

TABLE 27-2. CLASS RESULTS	
TIME IN MINUTES FOR COMPLETE CHANGE	NUMBER OF STUDENTS
0	0
2	
4	
6	
8	
10	
12	
14	
16	
18	
20	
22	
24	
26	
28	
30	

Analysis

1. Persons with little amylase in their saliva should take longer to digest the starch than persons with much amylase.
 - (a) What length of time did it take for your saliva to digest the starch? _____
 - (b) How does your time compare to the time of other students? _____
 - (c) How does your salivary amylase enzyme amount compare to that of other students? _____

2. If the problem stated in the introduction were to become a reality, some students in your class would be more likely to survive.
 - (a) Which students (those with longest or shortest times to change starch) would more likely survive? _____
 - (b) Explain. _____
3. (a) Do your experimental class results show that there are various amounts of salivary amylase enzyme in saliva? _____
 - (b) Explain. _____

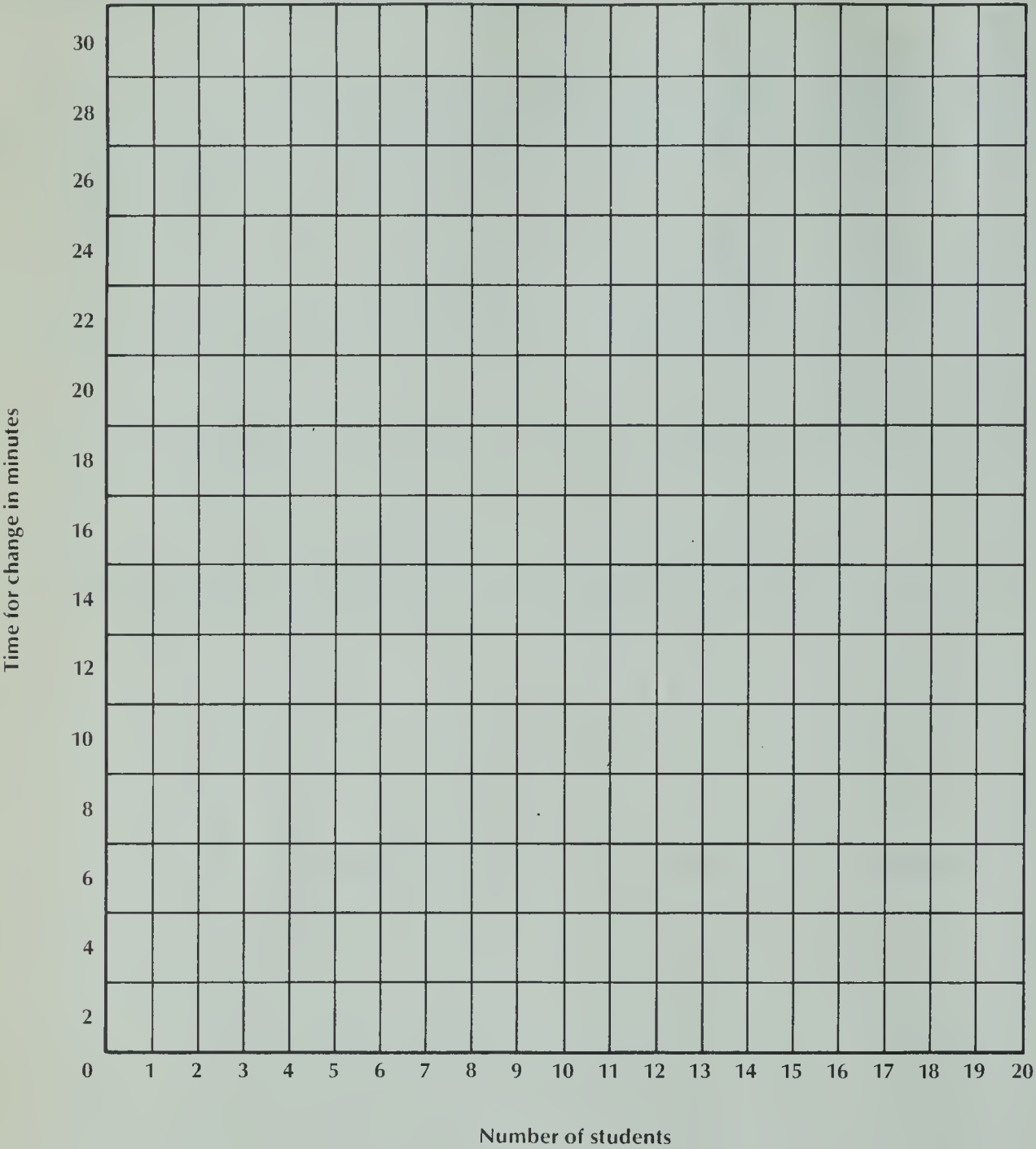
4. (a) Do your experimental class results show chemical differences among humans? _____
 - (b) Explain. _____

5. Explain survival of the fittest in terms of the starch change in diet. _____

6. (a) Why do some people have more salivary amylase enzyme than others? (Is it genetic?) _____

 - (b) Having different enzyme amounts in different people is called variation. When did the chemical variation occur (before or during the experiment)? _____
 - (c) Do you think most variations occur before they are adaptive? _____
 - (d) Explain. _____

7. Prepare a horizontal bar graph using your data from Table 27-2 and the graph outline below.



ANIMAL ADAPTATIONS

28

There are many different kinds of animals living in almost every different type of environment on the earth. Most seem well suited to their specific places because they have certain adaptations (traits) that aid their survival and reproduction in those specific environments.

In this investigation, you will

- determine which color, black or white, absorbs more light and, therefore, heats up faster.
- learn about a lizard color change adaptation.
- predict how skin color change can be a helpful adaptation.

Materials

thermometers - 2	lamp (goose neck)
black paper	metric ruler
white paper	empty frozen juice cans - 2
tape	clay

Procedure

- Cover a juice can with black paper. Tape the paper in place.

- Place a thermometer into the hole in the top of the can and secure it in place with clay. Make sure the hole is tightly sealed with clay. Use Figure 28-1A as a guide.

- Prepare a second can in the same manner, except use white paper instead of black.

- Place both cans in front of a lamp. The lamp should be 5 cm from both cans (see Figure 28-1B). DO NOT turn on the lamp.

FIGURE 28-1

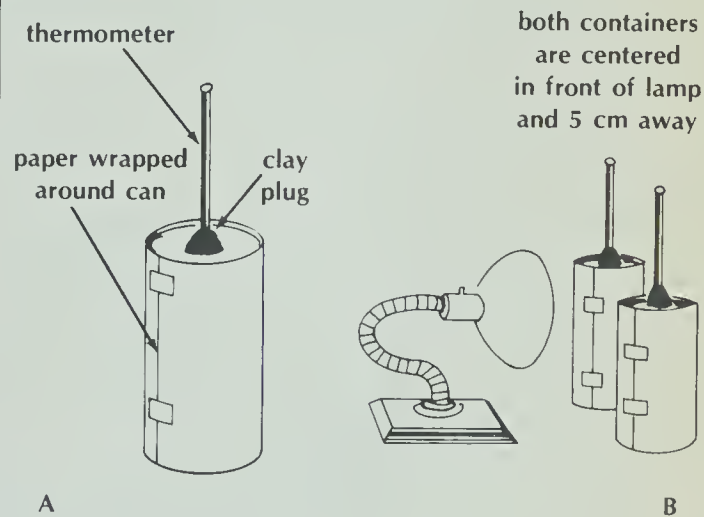


TABLE 28-1. TEMPERATURE READINGS FOR BLACK AND WHITE CANS

	STARTING TEMPERATURE	FINAL TEMPERATURE	TOTAL TEMPERATURE CHANGE IN 10 MINUTES
Black can			
White can			

● Record the starting temperature of both cans in Table 28-1.

● Turn on the lamp and allow it to shine on the cans for 10 minutes.

● At the end of this time, record the final temperature of both cans in Table 28-1. Calculate the total change in temperature for each can and record it in Table 28-1.

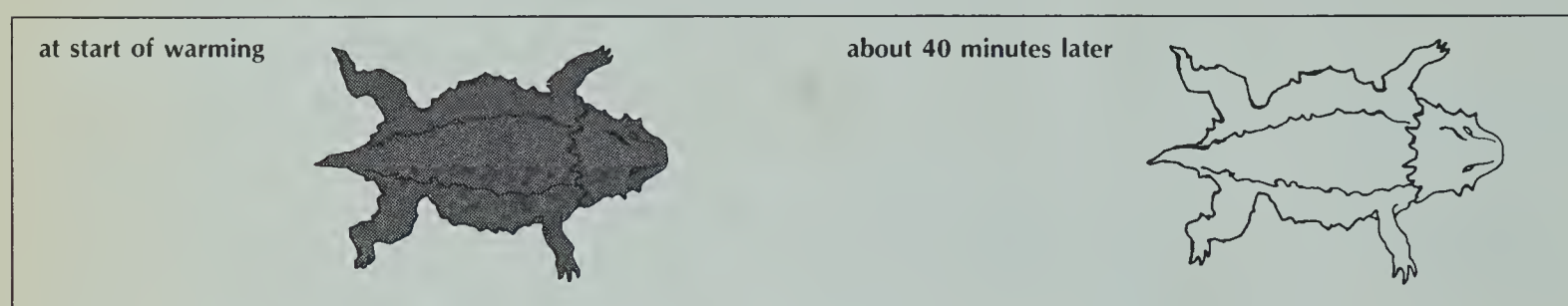
Analysis

1. (a) Which color, black or white, had the greater temperature change after ten minutes of heating from the lamp? _____

(b) Which color, black or white, absorbs light better and, therefore, warms up faster? _____

(c) Which color reflects light better and, therefore, warms up slower? _____

Examine the following two diagrams of the regal horned lizard. This type of lizard frequently can be found warming in the sun. It warms as it absorbs light from the sun.



2. (a) Which should absorb more light from the sun, the dark or the light lizard? _____

(b) Why? (Base your answer on what you observed in the experiment.) _____

3. Once the lizard reaches a certain body temperature, its skin turns lighter. Why does this color change occur? _____

4. The ability to change skin color is an adaptation. Explain how this adaptation may help these lizards to survive. _____

5. Predict what might occur if the lizard stayed in the sun and

(a) remained light in skin color all day. _____

(b) remained dark in skin color all day. _____

6. Adaptations are inherited.

(a) What may have happened in time to those lizards who could not change color? _____

(b) What may have happened in time to the genetic trait that prevented lizards from changing skin color? _____

7. The regal horned lizard lives throughout the western United States. Its scientific name is *Phrynosoma solare*.

(a) What does the word *solare* refer to? _____

(b) Why is this a good name for this animal? _____

SEED ADAPTATIONS

29

Adaptations are often thought to be only characteristic of animals. However, adaptations are evident in all living things, including plants.

In this investigation, you will

- (a) determine if water temperature can alter the amount of seed germination.
- (b) determine if scraping seed coats can alter seed germination.
- (c) explain how seed adaptations may aid plant survival and reproduction.

Materials

honey locust seeds—40
small beakers—2
plastic lunch bags—4
coarse sandpaper
hot plate
water
masking tape and pen
paper towels

Procedure

Part A. Seed Coat and Water Temperature

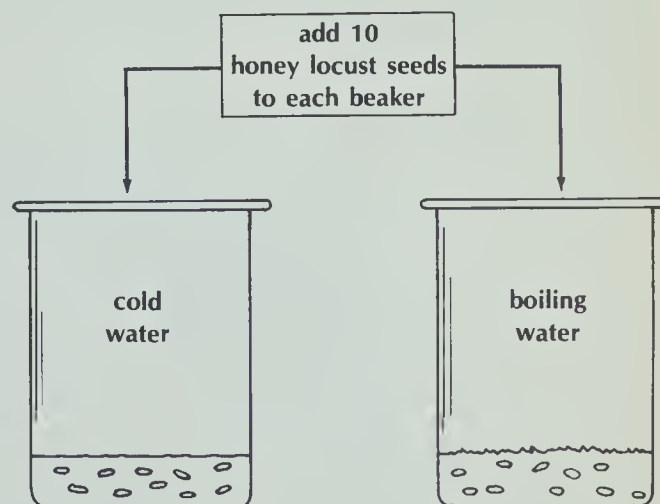
● *Step 1.* Using a hot plate, heat a small amount of water in a beaker to boiling. **CAUTION:** *Do not touch beaker with unprotected hands. Glass, water, and plate are hot.* Put the same amount of cold water into a second beaker.

● *Step 2.* Prepare both beakers as shown in Figure 29-1. There should be ten seeds in each beaker.

● After 15 minutes, remove all seeds from the beakers. Wrap each group of seeds in separate paper towels.

● Moisten each towel and place it in a plastic lunch bag. Use Figure 29-2 as a guide.

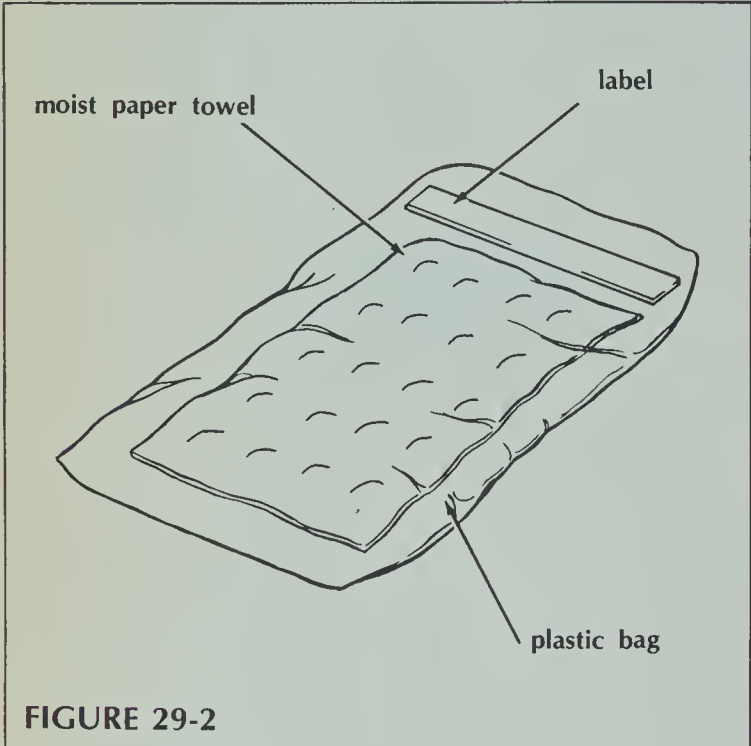
FIGURE 29-1



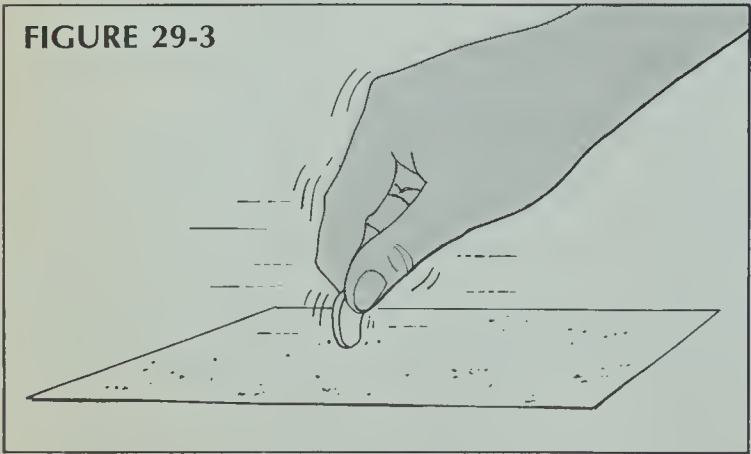
- Label each bag with your name, the date, and the treatment given the seeds. Label each bag as either "hot" or "cold" depending on whether the seeds were soaked in hot or cold water.
- Set the bags aside for 48 hours.

Part B. Seed Coat and Scraping

- Place ten honey locust seeds between wet paper towels. Place the towels and seeds in a plastic bag.



- Label this bag with your name, the date, and "unscraped."
- Prepare ten scraped honey locust seeds. While holding a honey locust seed tightly between your fingers, press rather hard as you rub the same spot of the seed across the surface of a piece of coarse sandpaper. Rub each seed exactly ten times. Use Figure 29-3 as a guide.



- Place these seeds between wet paper towels. Place the towels and seeds in a plastic bag.
- Label the bag with your name, the date, and "scraped."
- Set the bags aside for 48 hours.

Part C. Accumulation of Data

- After 48 hours, open each seed bag and count the number of seeds that have germinated.

A seed has germinated if there is a root extending from the seed. However, seeds about to germinate will be swollen to almost double their original volume due to water intake. Because honey locust seeds may not have formed roots in 48 hours, consider swollen seeds as having germinated (Figure 29-4).



honey locust seeds (natural size)
nongerminated

germinated


FIGURE 29-4

- Record individual data in Table 29-1.
- Calculate the percentage of germination by using the following equation.

$$\frac{\text{Number of germinated seeds}}{\text{Total number of seeds}} \times 100 = \text{percentage of germination}$$
- Record the percentages in Table 29-1.
- Total and record class results in Table 29-2.

**TABLE 29-1. NUMBERS AND PERCENTAGES OF GERMINATED SEEDS
INDIVIDUAL RESULTS**

TREATMENT	NUMBER OF SEEDS USED	NUMBER THAT GERMINATED	PERCENTAGE OF GERMINATION
Hot water			
Cold water			
Scraped			
Unscraped			

**TABLE 29-2. NUMBERS AND PERCENTAGES OF GERMINATED SEEDS
CLASS RESULTS**

TREATMENT	NUMBER OF SEEDS USED	NUMBER THAT GERMINATED	PERCENTAGE OF GERMINATION
Hot water			
Cold water			
Scraped			
Unscraped			

Analysis

- A seed coat serves as a barrier to germination. Water must penetrate this barrier for the seed to germinate.
 - Does the hard coat of honey locust seeds block or allow cold water to pass through? (Use class results from Table 29-2.) _____
 - Does the hard coat of honey locust seeds block or allow hot water to pass through? (Use class results from Table 29-2.) _____
 - At which temperature is water better able to pass through the seed coat? _____
- Honey locust seeds are formed in the late fall. The seeds may fall to the ground in the early winter.
 - Would the water temperature in soil in early winter be warm or cool? _____
 - Could water easily pass through the seed coat of honey locusts at this time? _____
 - Will honey locust seeds start to germinate at this time? _____
 - Explain. _____
 - Would young honey locust trees have a good chance to survive if they started growing in the winter? _____

3. Honey locust seeds remain in the soil until the following spring or summer.
- (a) Would the water temperatures in soil during spring or summer be warmer or colder than in winter?_____
- (b) Could water more easily pass through the seed coat of honey locust seeds at this time?_____
- (c) Would young honey locust trees have a good chance to survive if they started growing in the spring?_____
4. Seed response to water temperature is an inherited genetic trait. Seeds that germinate in nature during cold weather will not survive. Seeds that germinate in nature during warm weather will have a better chance of surviving. This ability to germinate only in warm weather is called an adaptation.
- (a) Which seeds are naturally selected to survive, those that germinate in cold or warm weather?_____
- (b) Which seeds are selected against (do not survive)?_____
- (c) Which trait is passed on to future generations?_____
5. (a) Does the scraped seed coat of honey locust seeds block or allow water to pass through? (Use class results from Table 29-2.)_____
- (b) Support your answer to (a) using specific class totals. _____
6. (a) Assuming that honey locust seeds fall to the ground in late fall or early winter, other than water temperature, what factor seems to prevent early seed germination?_____
- (b) Could this seed coat barrier to germination have any adaptive value? (Is it helpful?) _____
- (c) Explain what is meant by adaptive value._____
7. Suggest a possible way that the seed coat of a honey locust might be "scraped" in nature._____
8. Name the two honey locust seed adaptations that were studied in Part A and B of this experiment._____
9. (a) Do adaptations help or harm survival of organisms?_____
- (b) Define the term "adaptation."_____
10. Why are class data used to draw conclusions rather than individual data?_____
11. Describe an adaptation shown by
- (a) climbing vines._____
- (b) cactus plants._____

EVOLUTIONARY CHANGES IN PRIMATES

30

When paleontologists discover fossils, they determine whether they have discovered fossils of recent or early organisms. They then determine the kinds of organisms the fossils represent. If a skull were discovered and determined to be a primate skull, the next step would be to determine whether it is of an ape or a human. Because evolutionary change has occurred in both groups, the skull could be of early or modern ape or early or modern human. Because humans and apes evolved along separate lines, certain physical characteristics can be used in an attempt to classify the fossil skull as belonging to either ape (early or modern), early human, or modern human. Techniques similar to the ones used in this investigation are used by anthropologists, paleontologists, and archeologists.

In this investigation, you will

- examine gorilla, early human, and modern human skull diagrams.
- measure or observe and record specific skull structures and features.
- evaluate evolutionary changes that have occurred in these organisms.

Materials

metric ruler
protractor

Procedure

Part A. Skull Characteristics

Brain Area Compared To Face Area

The rectangles over the skulls in Figure 30-1 represent the area of the brain (upper rectangle) and face (lower rectangle) of each skull.

- Determine the area of each rectangle by measuring the length and width in centimetres and multiplying the two measurements together.

- Record in lines one and two of Table 30-1 the brain and face areas for the gorilla, *Paranthropus*, and modern human skulls.

A comparison can be made as to whether the brain area is larger or smaller than the face area.

- Compare the brain and face areas and complete lines 3, 4, and 5 of Table 30-1.

Cranial Capacity

- Measure the diameter in centimetres of the circle in each skull. The diameter is the distance across the exact center of each circle.

- Multiply the cranial diameters by 200 cm^2 . This gives the cranial capacity (brain volume) in cubic centimetres.

- Record the cranial capacity for each skull in line 6 of Table 30-1.

NOTE: This method of measuring cranial capacity differs from the method used when an intact skull is available.

Jaw Angle (Prognathism)

In front of each skull are two heavy lines, one running parallel to the slope of the upper jaw and one running through the nose. These two lines are to be used for measuring how far the jaw protrudes forward.

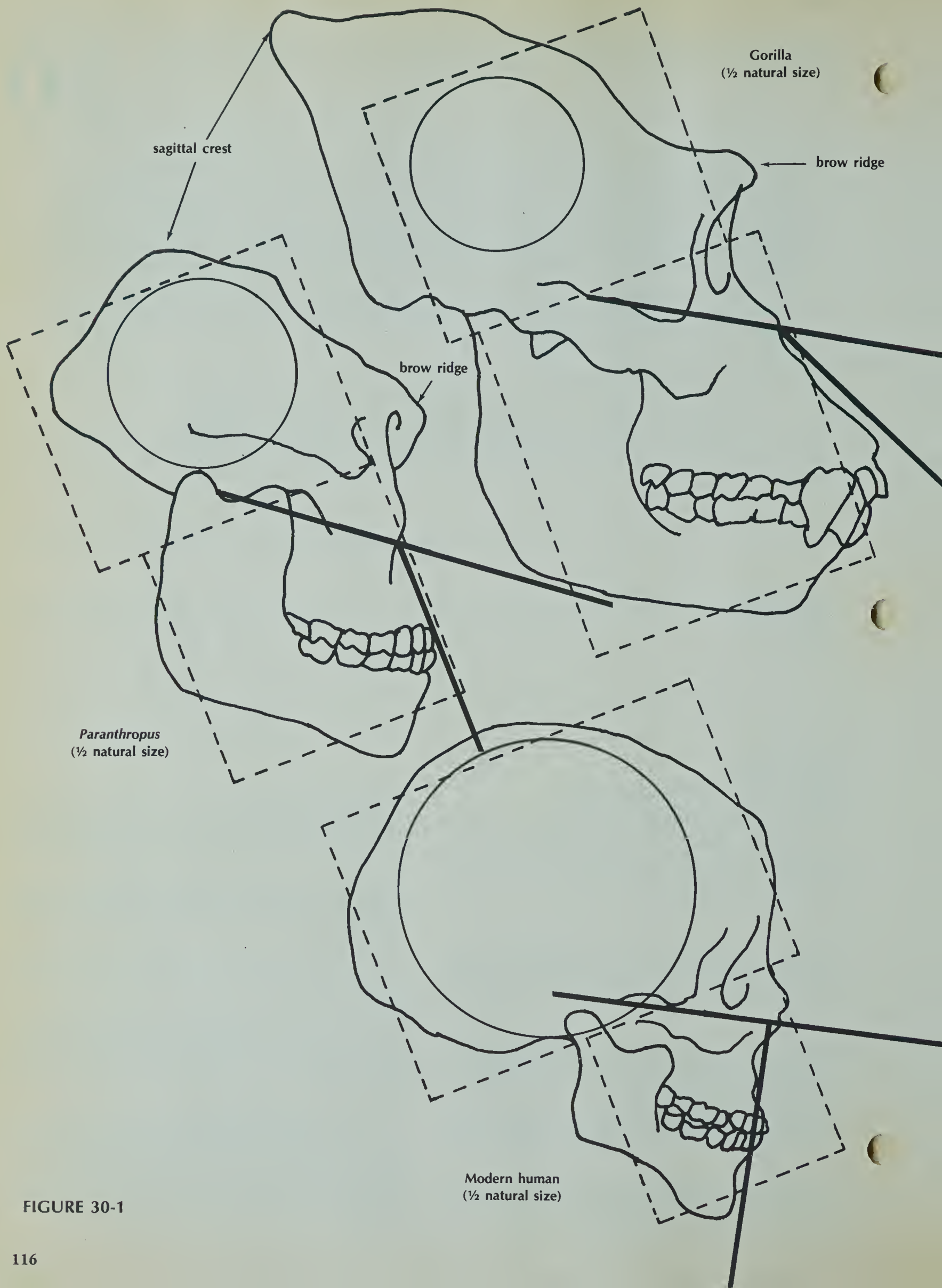
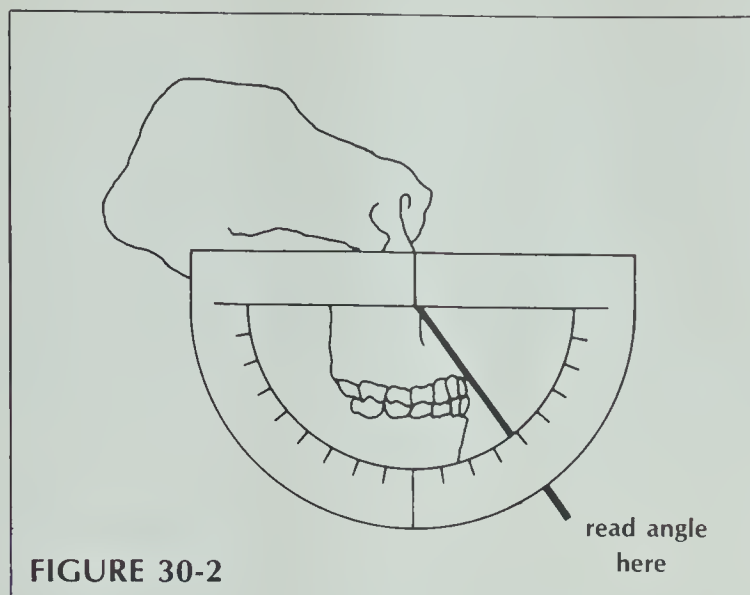


FIGURE 30-1

- With a protractor, measure the outside angle formed by the two lines in each skull (the angle toward the right).



- Place the protractor onto each skull as shown in Figure 30-2. Read the angle by using the outside scale on the protractor. The angle is read where the lower skull line crosses the protractor.

- Record the angles in line 7 of Table 30-1. An angle of less than 90° means that the lower jaw sticks out in front of the nose. An angle of 90° means that the lower jaw does not stick out in front of the nose. Complete line 8 of Table 30-1.

Sagittal Crest

A bony ridge running across the top of a skull for muscle attachment is called a sagittal crest.

- Indicate in line 9 of Table 30-1 whether a sagittal crest is absent or present in each skull. Refer to Figure 30-1.

Brow Ridge (Supraorbital Ridge)

Directly above the eye sockets is a thick bony ridge. This ridge may be absent or present in a skull.

- Indicate in line 10 of Table 30-1 whether or not a brow ridge is present.

Numbers and Types of Teeth

Use the diagrams on page 116 for this part of the investigation.

- Count and record the number of teeth for each lower jaw in line 11 of Table 30-1.

- Count the number of each tooth type for each lower jaw. "M" on Figure 30-3 is for molar, "P" is for premolar, "C" is for canine, and "I" is for incisor.

- Record in lines 12 to 15 of Table 30-1 the tooth type totals.

Lower Jaw Shape

The distance across the jaw backs compared to the distance across the jaw fronts can be used to determine jaw shapes of the three organisms in Figure 30-3 on page 119.

- Measure in centimetres the distance across each jaw from one dot to the other on the back molar teeth.

- Measure the distance across each jaw using the dots on the front pre-molar teeth.

- Record the distances for each jaw in lines 16 and 17 of Table 30-1. The distance across the back and front of a lower jaw will help to determine if the jaw is U- or V-shaped.

If the distance across the back of the jaw is the same as the distance across the front of the jaw, the jaw has a U shape. If the distance across the back is greater than the distance across the front, the jaw has a V shape. Complete lines 18, 19, and 20 of Table 30-1.

Part B. Interpretation of Data

The following information will help you evaluate your recorded data and answer the questions in the Analysis.

Brain Area Compared to Face Area

A larger brain area compared to face area is a trait of modern humans.

Cranial Capacity

An increase in brain size as measured by cranial capacity is characteristic of more complex organisms. Modern humans have the largest cranial capacity of all closely related primates.

Jaw Angle

Jaw angle increase toward 90° is a trait of modern humans. Less of a protruding jaw is characteristic of more complex organisms.

TABLE 30-1. COMPARISON OF GORILLA, *PARANTHROPUS*, AND MODERN HUMAN SKULLS

	GORILLA	<i>PARANTHROPUS</i>	MODERN HUMAN
1. Face area			
2. Brain area			
3. Is brain area smaller than face area?			
4. Is brain area larger than face area?			
5. Is brain area 3 times larger than face area?			
6. Cranial capacity in cm ³			
7. Jaw angle			
8. Does lower jaw stick out in front of nose?			
9. Sagittal crest present			
10. Brow ridge present			
11. Number of teeth in lower jaw			
12. Number of molars in lower jaw			
13. Number of premolars in lower jar			
14. Number of canines in lower jaw			
15. Number of incisors in lower jaw			
16. Distance across back of jaw			
17. Distance across front of jaw			
18. Is distance across front and back of jaw the same?			
19. Is lower jaw U-shaped?			
20. Is lower jaw V-shaped?			

Sagittal Crest

This bony ridge is associated with heavy temporal muscles used to move the lower jaws. As the lower jaw gets smaller, so does the sagittal crest.

Brow Ridge

Loss of this ridge is a trait of modern humans. NOTE: Most anthropologists believe that *Paranthropus* evolved along with gorillas and humans. It cannot and should not be assumed that the progression of evolutionary change was from gorilla to *Paranthropus* to modern humans. *Paranthropus* is used here to illustrate many traits believed to have been associated with early

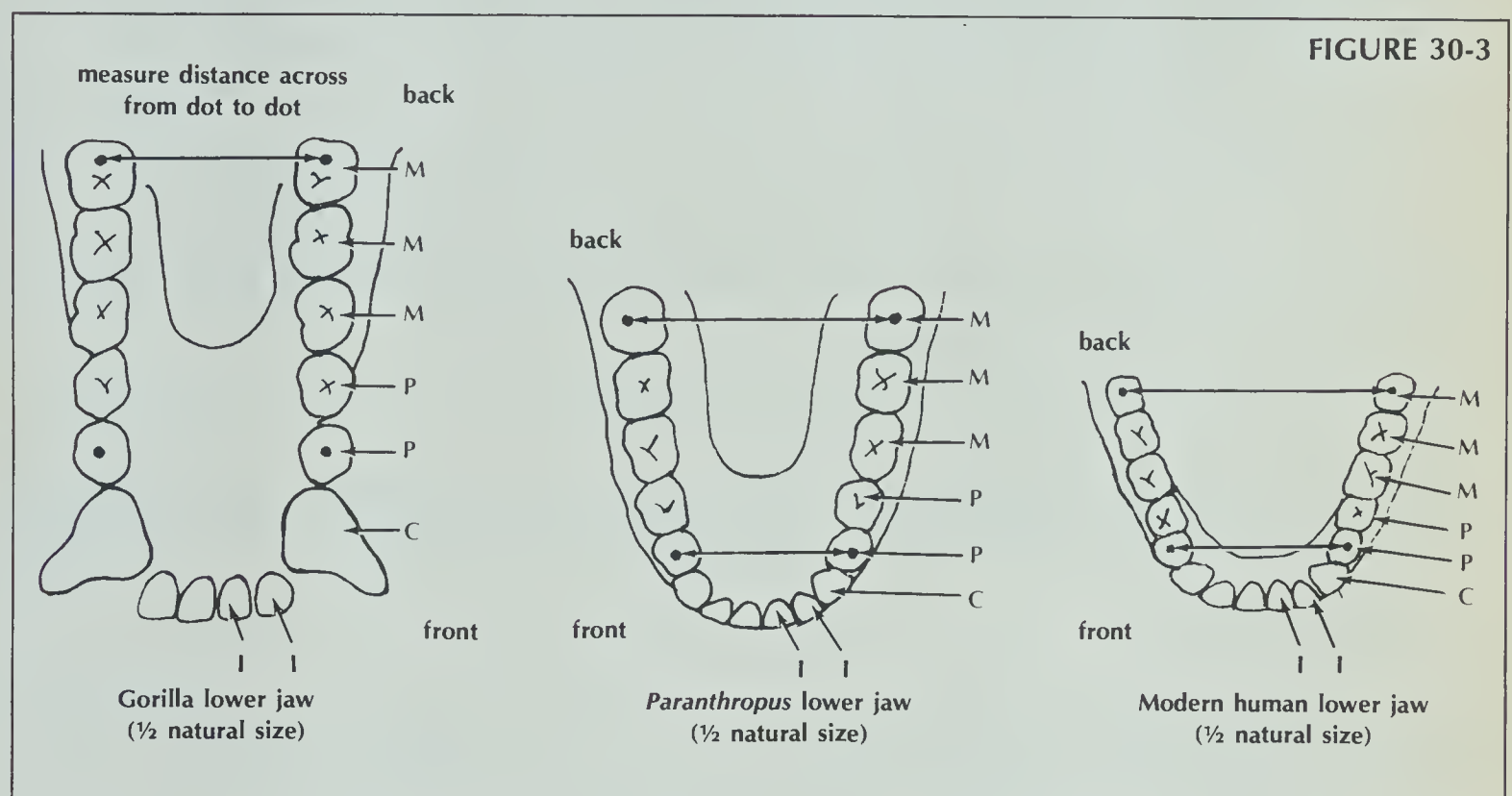
humans. All three animals probably evolved from some common primate ancestor. Use *Paranthropus* traits only as a means of distinguishing among modern humans, early humans, and gorillas.

Numbers and Types of Teeth

Adult modern humans, *Paranthropus*, and gorillas all have similar patterns in terms of numbers and types of teeth.

Lower Jaw Shape

Gorillas have a jaw in which both sides are parallel to one another. They have a U-shaped jaw. Modern humans have a V-shaped jaw.



Analysis

1. (a) What change in brain area has occurred when gorilla is compared to modern humans? _____

- (b) What change in face area has occurred when gorilla is compared to modern humans? _____

- (c) Which animal in this investigation shows the largest brain area and smallest face area? _____

2. How does the cranial capacity of *Paranthropus* compare to that of the

(a) gorilla? _____

(b) modern human? _____

3. How do the lower jaws of these three animals compare in regard to

(a) number of teeth? _____

(b) number of molars? _____

(c) number of premolars? _____

(d) number of canines? _____

(e) number of incisors? _____

(f) jaw shape? _____

4. How many traits are similar when comparing

(a) gorilla to *Paranthropus*? _____

(b) *Paranthropus* to modern human? _____

(c) gorilla to modern human? _____

5. Based on your answer to question 4, does a modern human seem to be closer in evolutionary development to gorilla or *Paranthropus*? _____

6. Based on your answer to question 4, does *Paranthropus* seem to be rather close in evolutionary development to both gorilla and modern human? _____

7. Suppose you find a distorted fossil jawbone and note that there are 16 teeth in it. Explain why this information may or may not be helpful in determining whether the fossil is from a modern or early human or gorilla. _____

8. Suppose you find a distorted jawbone with most of the teeth missing. The canine teeth, however, are present and appear to be quite large. Which animal might this jaw be from? _____

Explain. _____

9. Suppose you find only the top portion of a skull. No sagittal crest seems to be present, nor is there any evidence that one may have ever been present. Which animal might this skull be from? _____

Explain. _____

10. Suppose you find a skull with 22 teeth. Might this skull be from a primate? _____

Explain. _____

CLASSIFICATION

31

You are constantly using systems of classification in everyday life. For example, you are classified by year in school, age, and color of hair. A phone book or a coin collection are other examples of information or items that are classified for ease in handling.

Taxonomy is that area of life science dealing with classification of living organisms. The value of a classification system to science is threefold. First, it shows relationships among organisms by grouping together living things that have similar characteristics. Second, the last two divisions of the classification system give the scientific name for each organism. Third, the two word name of an organism in the classification system is the same worldwide.

Group names have been established to simplify the complex process of classifying living things. For example, the largest group is referred to as a kingdom. Each kingdom is divided into several smaller groups called phyla (singular, phylum). After successive divisions into smaller and smaller groups, the genus and species are reached. Each living thing is named by its genus and species.

In this investigation, you will

- (a) prepare a classification of some common objects.
- (b) place these objects into kingdoms, phyla, and classes.
- (c) give names to each kingdom, phylum, and class.

Materials

thumbtack	test tube	match	chalk
glass slide	paper clip	penny	file card
seed	pin	wool strand	
rubber band	pencil	plastic tie	

Procedure

Part A. Forming Kingdoms

● Place the objects given to you into two groups. You decide what trait to use as a basis for separating the two groups. Call them Group 1 and Group 2. Equal numbers of objects do not have to be in each group.

1. List the objects that you placed into Group 1.

2. List the objects that you placed into Group 2.

3. What trait was used as a basis for placing objects

(a) into Group 1? _____

(b) into Group 2? _____

4. (a) Using the characteristic or trait in question 3a, design an appropriate but brief name for Group 1. The name should describe the trait you used. (For example, large size group or

metal group.) _____

- (b) Using the characteristic or trait in question 3b, design an appropriate but brief name for Group 2. The name should describe the trait

you used. _____

- If these had been living objects, they would have been placed into groups called kingdoms.

Many biologists group living things into five kingdoms—plants, animals, protists, monerans, and fungi.

Part B. Forming Phyla

- Return to the objects that belong only in Group 1. Regroup these objects into two new groups. Equal numbers of objects do not have to be in each group. Refer to these as Group 1A and Group 1B.

5. List the objects placed into Group 1A. _____

6. List the objects placed into Group 1B. _____

7. (a) What trait was used as the basis for grouping these objects into Group 1A? _____

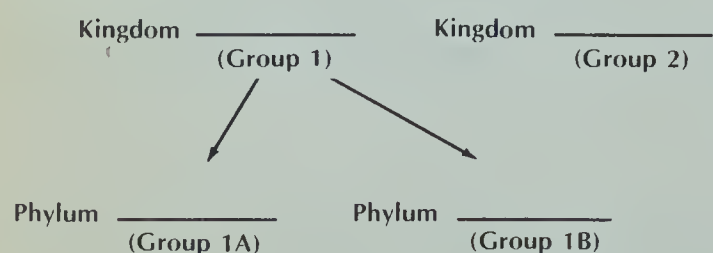
(b) Based on the trait used, design an appropriate but brief name for Group 1A. _____

8. (a) What trait was used as the basis for grouping these objects into Group 1B? _____

(b) Based on the trait used, design an appropriate but brief name for Group 1B. _____

- If these objects were living, they would have been placed into groups called phyla. Therefore, your answers to questions 7b and 8b are phylum names. There can be many phyla in each kingdom.

FIGURE 31-1



9. Complete Figure 31-1 of your classification scheme so far. Place in the spaces provided the brief name you used in questions 4a, 4b, 7b, and 8b.

10. Are all objects in both phyla also grouped into the same kingdom? _____

- Take the objects of Group 2 and regroup them into three phyla. You decide what to use as a basis for separating the three groups. Equal numbers of objects do not have to be in each group. Refer to these groups as Groups 2A, 2B, and 2C. These groups also would be phyla.

- Decide on brief names which could be used to describe the groupings you made.

11. Complete Figure 31-2 of your classification with the names you have chosen.

Part C. Forming Classes

- Objects in each phylum can be separated further into groups called classes. Each phylum may have several classes.

- Take only the objects in Phylum 2A and separate them into two classes. Refer to them as Groups 2AI and 2AII.

12. (a) Design an appropriate but brief name for Group 2AI. _____

(b) Design an appropriate but brief name for Group 2AII. _____

13. (a) Fill in the following information for any object in Class 2AI. Use the names you have chosen.

Kingdom _____

Phylum _____

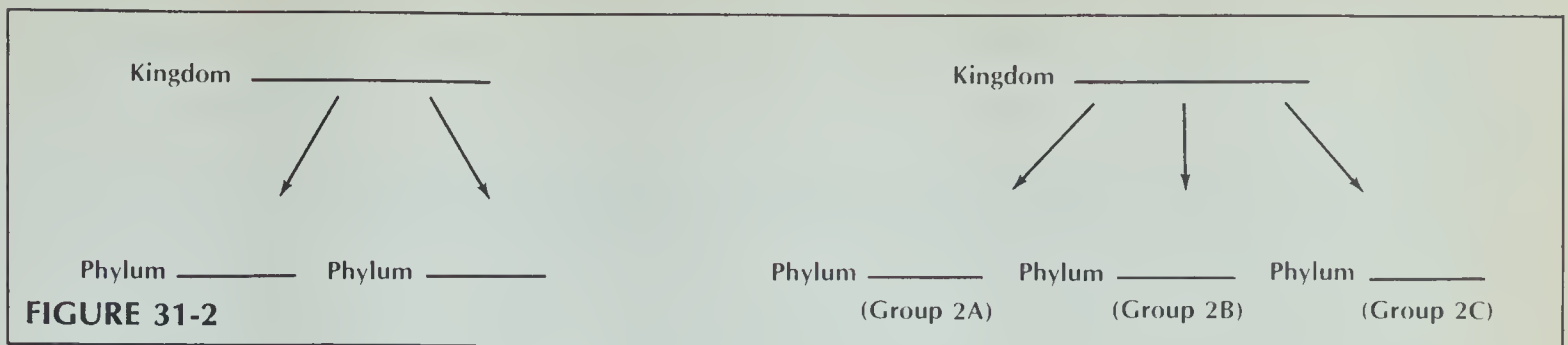
Class _____

(b) Fill in the following information for any object in Class 2AII. Use the names you have chosen.

Kingdom _____

Phylum _____

Class _____



14. (a) Must all objects in the same class also belong to the same phylum? _____
- (b) Must all objects in the same phylum also belong to the same kingdom? _____

• If you were to continue classifying the objects, new group names would appear. For example, classes are broken down into orders, orders into families, families into genera, and genera into species. Thus, the classification of living things is: kingdom, phylum, class, order, family, genus, and species.

Analysis

1. List three reasons scientists classify living organisms. (HINT: Read the introduction.)

2. List the first three group names used in classifications from largest to smallest groups. _____

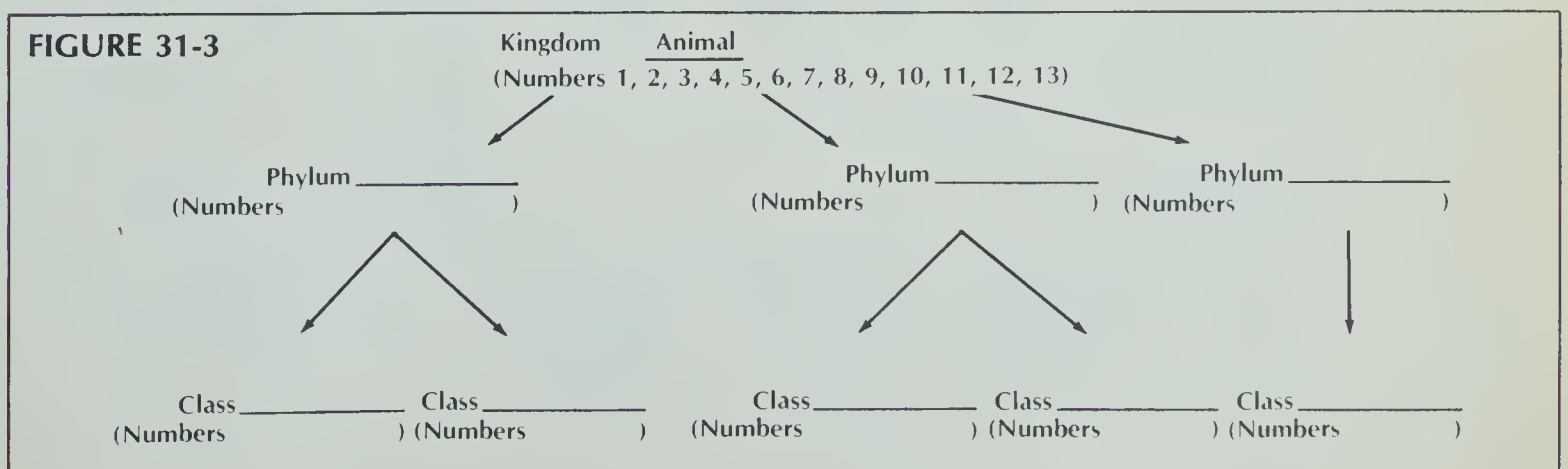
3. (a) In Part A, what trait did you use to form Group 1 (Kingdom 1)? _____

- (b) In Part A, what trait did you use to form Group 2 (Kingdom 2)? _____

- (c) If given a test tube cork and a nail, into which of your kingdoms would each of these two objects be placed? _____

4. All of the organisms on page 124 belong to the animal kingdom. Design a classification grouping the animals into the outline provided.

- (a) Using the numbers only of each animal, list those animals belonging to each phylum and class in the space marked Numbers.
- (b) Choose a suitable name for each phylum that helps to show the trait you used for your grouping. Write the name on the blank provided.



(c) Choose a suitable name for each class that helps to show the trait you used for your grouping. Write that name on the blank provided.

5. According to the classification scheme in question 4,

(a) must each phylum contain equal numbers of organisms? _____

(b) must each phylum be separated into the same number of classes? _____

6. A student grouped the animals on page 124 into the following two phyla:

Phylum I—numbers 1, 4, 5, 10, 12

Phylum II—numbers 2, 3, 6, 7, 8, 9, 11, 13

What may have been the basis for grouping the animals in this way? _____

7. A different student grouped the animals in Figure 31-4 into the following two phyla:

Phylum I—numbers 1, 3, 4, 5, 6, 7, 8, 9, 10, 12

Phylum II—numbers 2, 11, 13

What may have been the basis for grouping the animals in this way? _____

8. (a) Must all animals belonging to the same class also belong to the same phylum? _____

(b) Explain. _____

9. (a) Must all animals belonging to the same phylum also belong to the same class? _____

(b) Explain. _____

10. (a) In the animal kingdom, one phylum is the chordates. Humans, birds, snakes, and frogs belong to this phylum. What may be the trait being described in this phylum name? _____

(b) The class Amphibia contains frogs and salamanders. What may be the trait being described in this class name? _____

11. Do the traits being used to separate organisms into classes appear to be more general or more specific than those used in separating organisms into kingdoms? _____

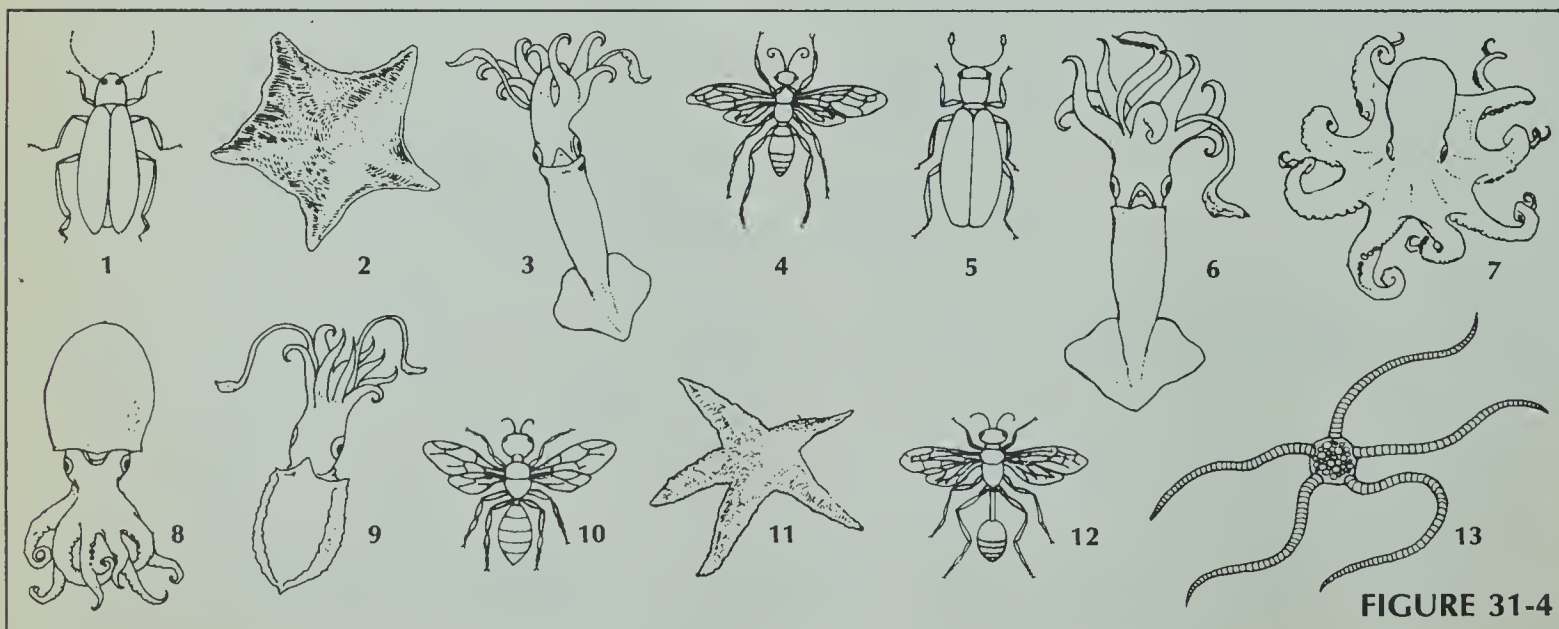


FIGURE 31-4

USING AND MAKING A BIOLOGICAL KEY

32

Classification is a way of separating a large group of closely related organisms into smaller subgroups. With a classification system, identification of an organism is easy. The scientific names of organisms are based on the classification systems of living organisms. To classify an organism, scientists often use a key. A key is a listing of specific characteristics, such as structure and behavior, in such a way that an organism can be identified.

In this investigation, you will

- (a) use a key to identify fourteen shark families.
- (b) study the method used in making statements of a key.
- (c) construct your own key which will identify organisms appearing on page 128.

Materials

metric ruler

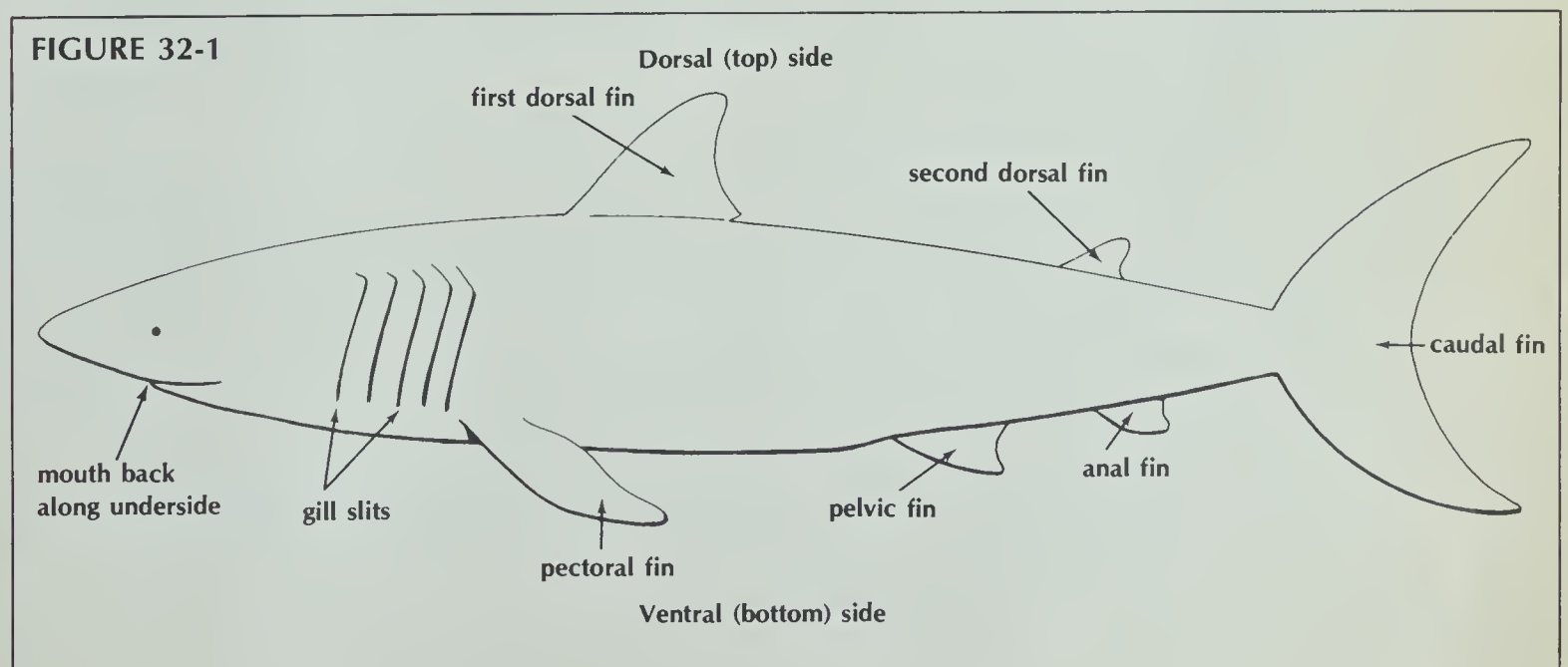
Procedure

- Use Figure 32-1 as a guide to the shark parts used in the key on page 127.

- Read sentences 1A and 1B of the key. Then study Shark 1 in Figure 32-2 for the characteristics referred to in 1A and 1B. Follow the directions in these sentences and continue until a family name for Shark 1 is determined.

For example, to key a shark that has an anal fin and a body that is not kite shaped, follow the directions of 1A and go directly to statement 2. To key a shark that lacks an anal fin and has a kite shaped body, follow the directions of 1B and go to statement 10.

- Continue this process with each shark until all animals have been identified. Write the family name on the line below each animal.



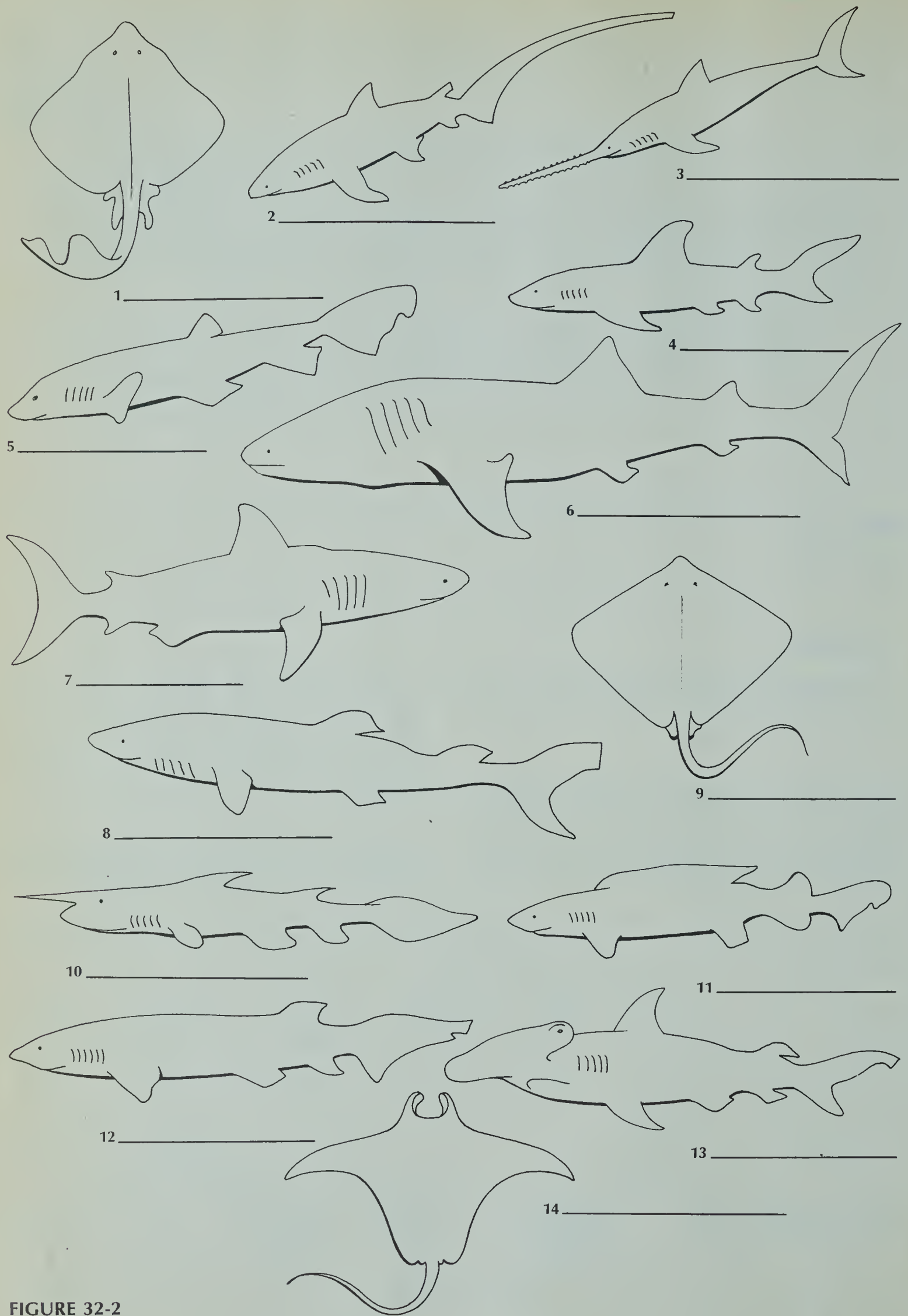


FIGURE 32-2

Key

1. A. Body kitelike in shape (if viewed from the top)..... Go to statement 12
 B. Body not kitelike in shape (if viewed from the top)..... Go to statement 2
2. A. Pelvic fin absent and nose sawlike..... Family Pristiophoridae
 B. Pelvic fin present..... Go to statement 3
3. A. Six gill slits present..... Family Hexanchidae
 B. Five gill slits present..... Go to statement 4
4. A. Only one dorsal fin..... Family Scyliorhinidae
 B. Two dorsal fins..... Go to statement 5
5. A. Mouth at front of head rather than back
 along underside of head..... Family Rhinocodontidae
 B. Mouth back along underside of head..... Go to statement 6
6. A. Head expanded on side with eyes at end of expansion..... Family Sphyrnidae
 B. Head not expanded..... Go to statement 7
7. A. Top half of caudal fin exactly same size and shape as bottom half..... Family Isuridae
 B. Top half of caudal fin different in size and shape than bottom half..... Go to statement 8
8. A. First dorsal fin very long, almost half total length of body..... Family Pseudotriakidae
 B. First dorsal fin regular length..... Go to statement 9
9. A. Caudal fin very long, almost as long as entire body..... Family Alopiidae
 B. Caudal fin regular length..... Go to statement 10
10. A. A long needlelike point on end of nose..... Family Scapanorhynchidae
 B. Nose without long point..... Go to statement 11
11. A. Anal fin absent..... Family Squalidae
 B. Anal fin present..... Family Carcharhinidae
12. A. Small dorsal fin present near tip of tail..... Family Rajidae
 B. No dorsal fin present near tip of tail..... Go to statement 13
13. A. Front of animal with two hornlike appendages..... Family Mobulidae
 B. No hornlike appendages..... Family Dasyatidae

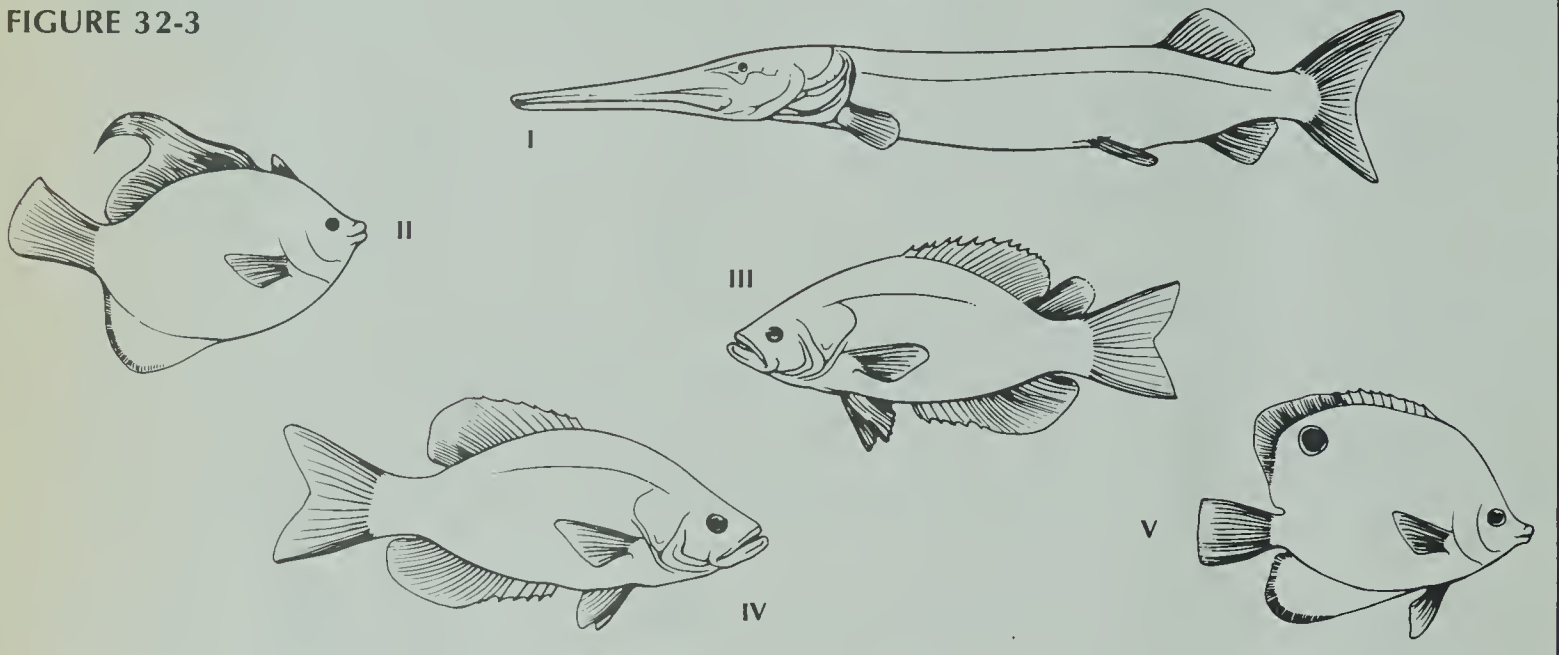
Analysis

1. What is a biological key and how is it used? _____

2. List four different characteristics or traits that were used in the shark key. _____

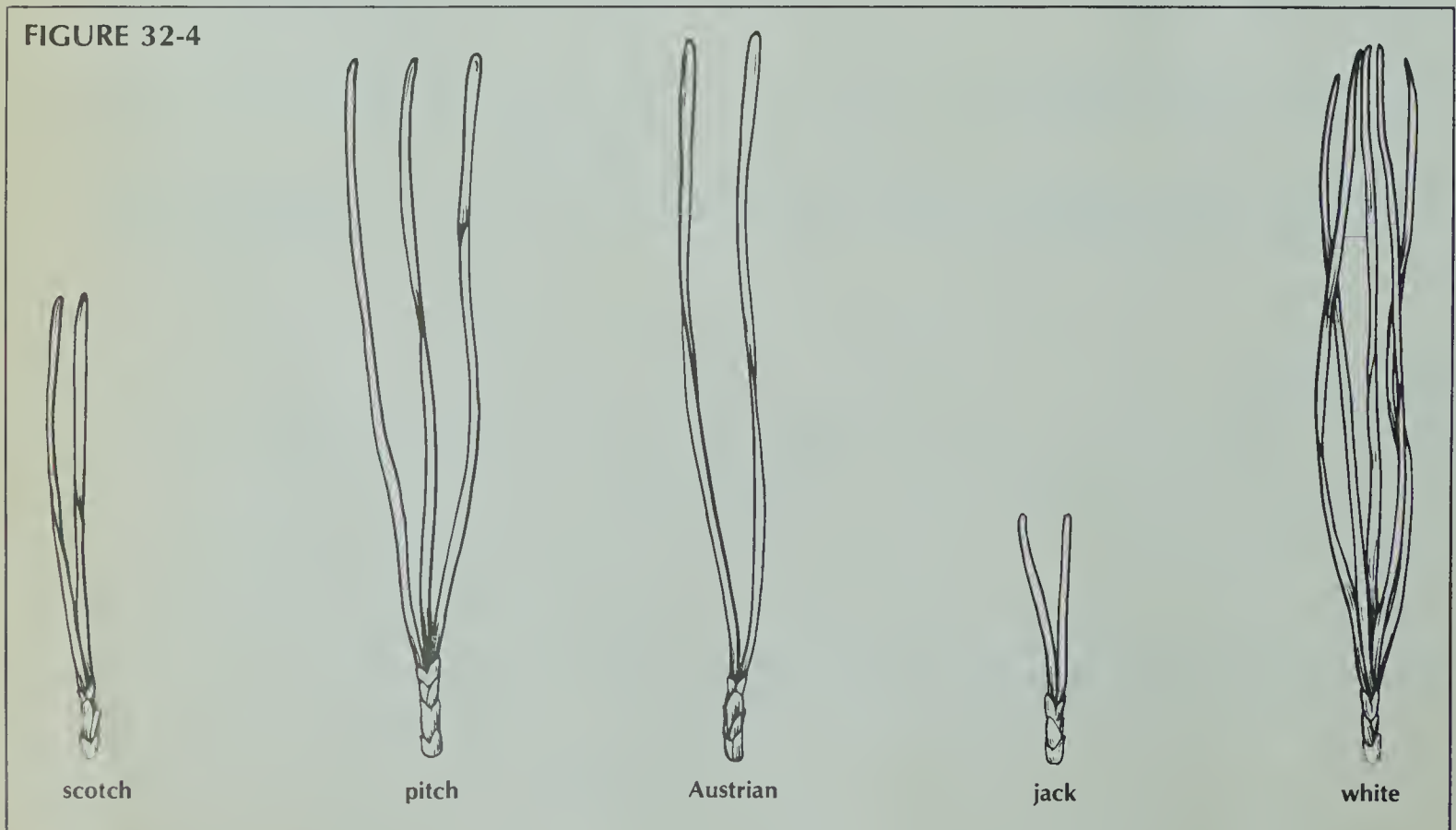
3. (a) What main trait could be used to separate shark 4 from shark 8? _____
- (b) What main trait could be used to separate shark 4 from shark 7? _____
- (c) What main trait could be used to separate shark 5 from shark 12? _____
4. Prepare your own key for the five fish in Figure 32-3. Use the same format as on page 127. The family names to be used are the numbers I, II, III, IV, and V. Your key should correctly use traits that will lead to each fish family. To help you get started, we have given you a suggestion for part of the first statements.
1. A. Fish with long tubelike body
 - B. Fish with regular body shape

FIGURE 32-3



5. These leaves (needles) in Figure 32-4 are all from different pine trees and are drawn life size. Note that each bundle contains different numbers and lengths of leaves. Design a key which will classify each tree.

FIGURE 32-4



A COMPARISON OF SOME MONERANS AND PROTISTS

33

Biologists today classify living things into five kingdoms. The first two are called the Monera and Protist Kingdoms. Most students are not familiar with the organisms in these two kingdoms because they are very small in size. Nevertheless, these organisms are important and are interesting to observe.

If a scientist places organisms into different kingdoms, there must be some sharp differences among the organisms. The main difference between these two kingdoms is that monerans are very small, usually only one cell in size, and they lack nuclei. Protists are also small, usually only one cell in size, but they do have nuclei.

In this investigation, you will

- examine organisms which belong to the moneran kingdom, observing and recording some of their major traits.
- examine organisms which belong to the protist kingdom, observing and recording some of their major traits.
- compare the traits of organisms belonging to these two kingdoms.

Materials

microscope
methylene blue stain
Merismopedia, preserved or living
Paramecium, prepared slide

Euglena, prepared slide
glass slide
coverslip
dropper

Procedure

Part A. Monerans

Blue-green algae and bacteria are examples of organisms belonging to Kingdom Monera. Bacteria are usually too small to study under the light microscope. Therefore, we will study only blue-green algae.

Figure 33-1 shows a greatly enlarged view (2000X natural size) of blue-green alga *Lyngbya*. Its special features are labeled for you.

Lyngbya has no nucleus. Although it appears multicellular, it is actually many separate cells joined in one threadlike pattern. Blue-green algae contains chlorophyll, but it is not contained in chloroplasts. Instead, the chlorophyll is spread evenly throughout the cytoplasm. Because it contains chlorophyll, blue-green algae can make its own food.

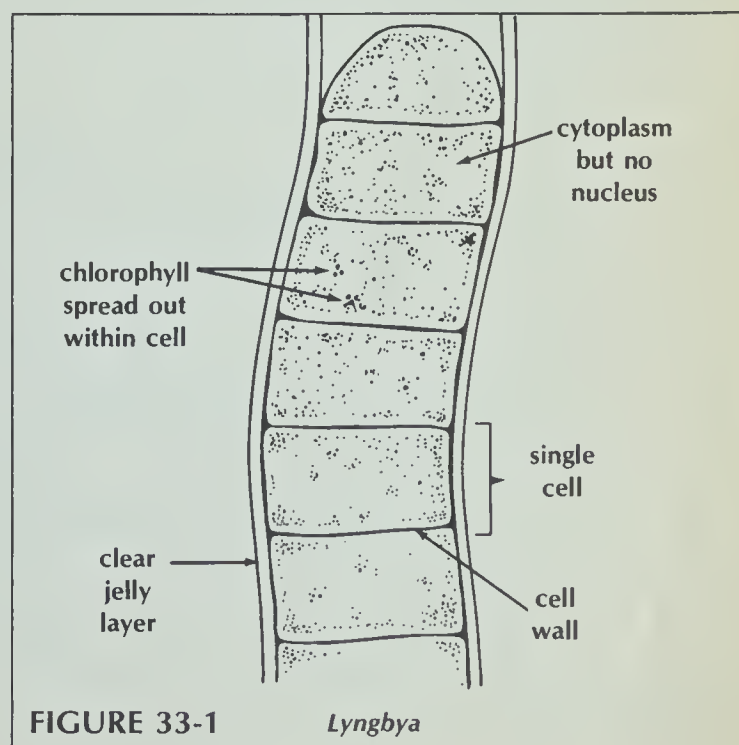
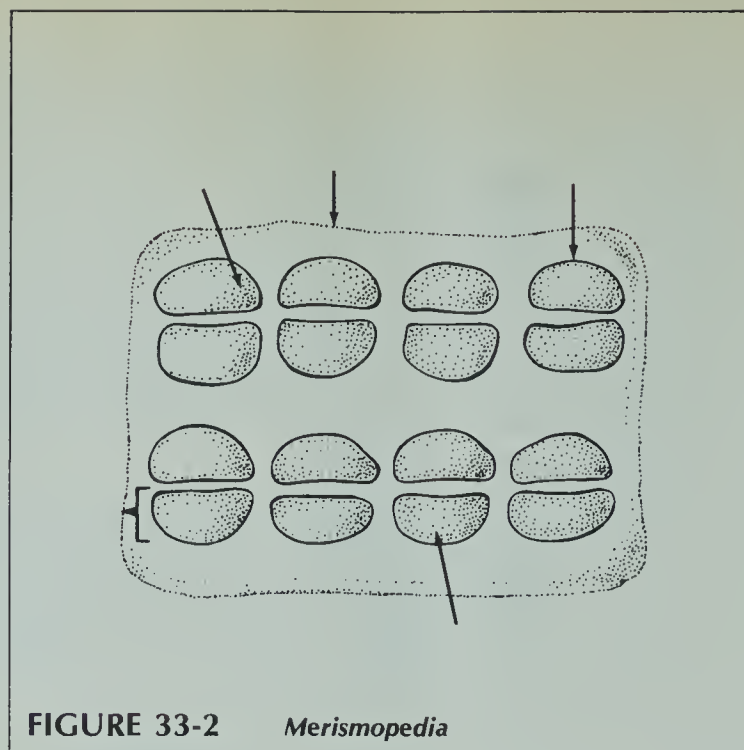


FIGURE 33-1

Lyngbya

- Prepare a wet mount of blue-green algae *Merismopedia*.
- Add one drop of methylene blue stain to the algae. Add a coverslip.
- Observe the algae under low and high powers. The stain will form a dark background, allowing you to see if *Merismopedia* is surrounded by a clear jelly layer.
- Label the following structures on Figure 33-2: cytoplasm, clear jelly layer, cell wall, single cell, chlorophyll spread out in the cell.

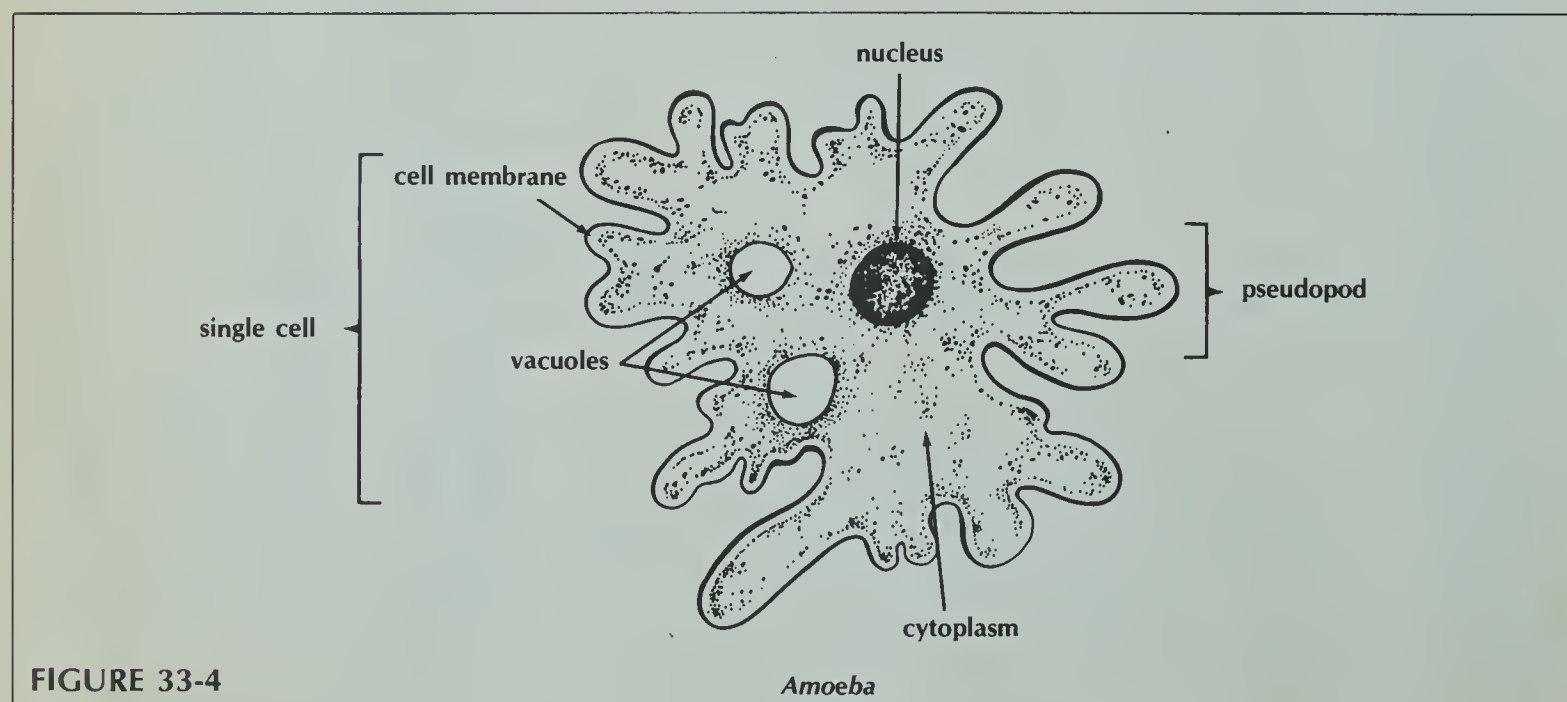
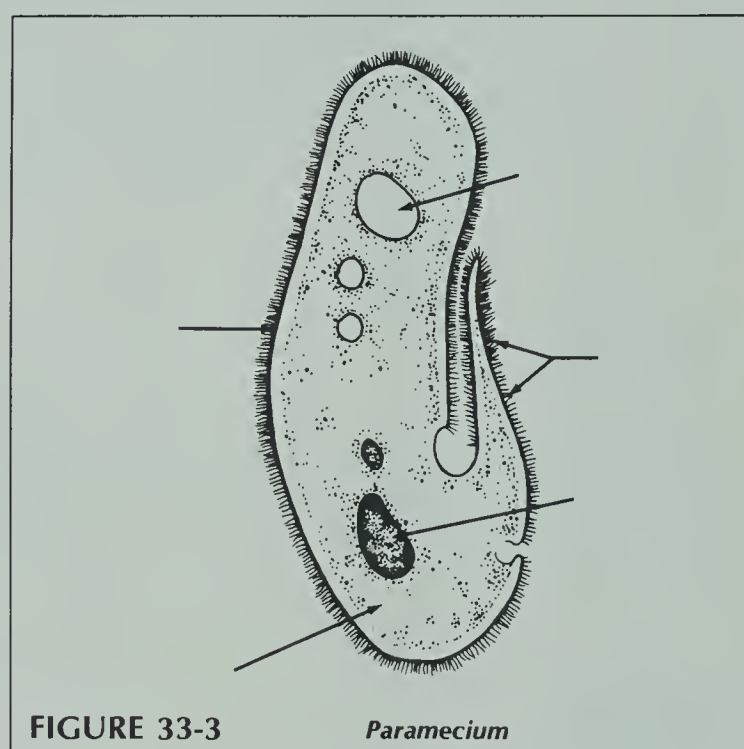


Part B. Protists

A wide variety of organisms belong to Kingdom Protista. However, these organisms share several common characteristics. Protists all have nuclei within their cells, and are usually unicellular.

Figure 33-4 shows a greatly enlarged view (2000X natural size) of a protist called *Amoeba*. Amoebae move by extending parts of their cytoplasm. These extensions are called pseudopodia. The special features of *Amoeba* are marked for you on Figure 33-4.

- Examine a prepared slide of a protist called *Paramecium*.
- Observe *Paramecium* under low and high powers. Attempt to locate the many tiny hairlike parts called cilia which stick out from the cell membrane. Cilia beat the water, and move the *Paramecium* from place to place.

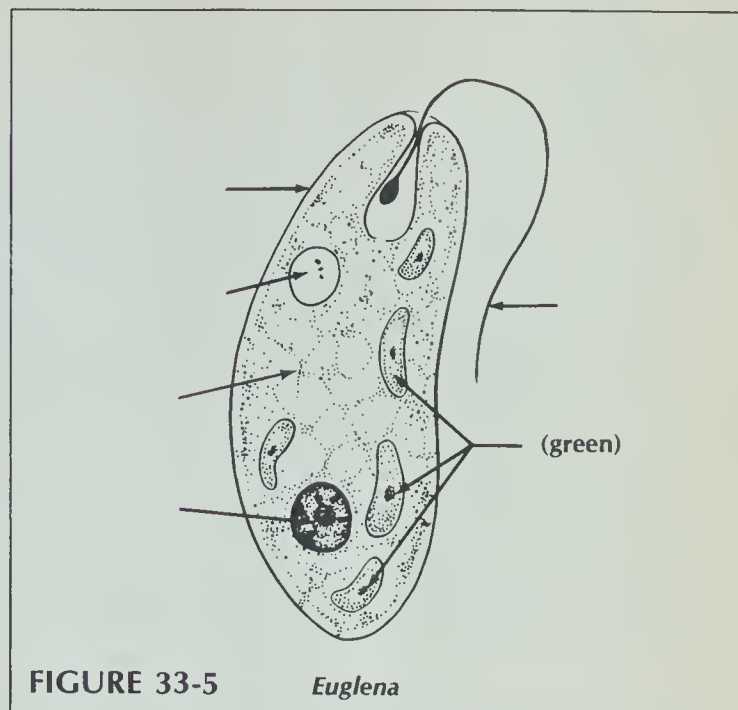


● Label the following structures on Figure 33-3: *vacuole, nucleus, cytoplasm, cell membrane, cilia, single cell.*

● Examine a prepared slide of a protist called *Euglena*.

● Observe *Euglena* under low and high powers. Attempt to locate a single hairlike structure called a flagellum. The flagellum moves *euglena* through the water. *Euglena* are green due to the presence of chlorophyll. The chlorophyll is contained within a cell part called a chloroplast. *Euglena*, like blue-green algae can make its own food.

● Label the following structures on Figure 33-5: *flagellum, nucleus, vacuole, cell membrane, cytoplasm, chloroplasts, single cell.*



Analysis

1. Complete this chart which compares all organisms observed or studied in this lab.

	LYNGBYA	MERISMOPEDIA	AMOEBA	PARAMECIUM	EUGLENA
Kingdom					
Microscopic?					
Nucleus present?					
Chlorophyll present?					
Chloroplasts present?					
Makes own food?					
Can move by itself?					
Structure used for movement					
Jelly layer present?					

2. (a) Explain how organisms in Kingdom Protista differ from those in Kingdom Monera. _____

(b) Which kingdom may be more primitive? _____

(c) Explain. _____

3. (a) Are all organisms in Kingdom Protista capable of producing their own food? _____

(b) Give evidence to support your answer. _____

4. (a) Are some organisms belonging to the Kingdom Monera capable of producing their own food? _____

(b) Give evidence to support your answer. _____

5. The following one-celled organisms were observed by a student. Decide if each is a member of Kingdom Monera or Protista.

(a) Write the kingdom name below each organism in the space provided.

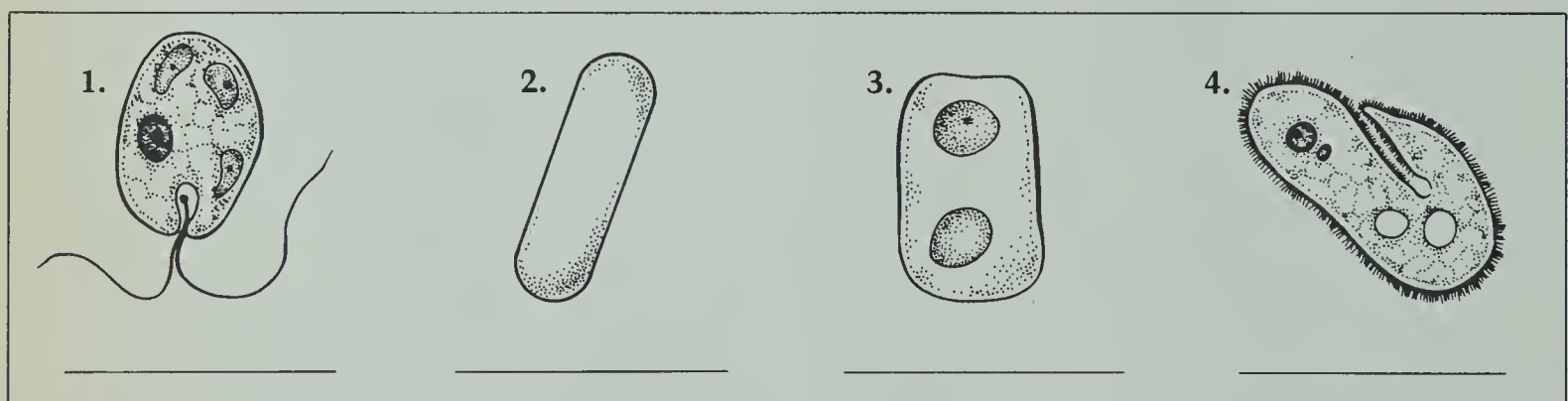
(b) What trait (or traits) helped you decide to which kingdom each organism belonged?

Organism 1: _____

Organism 2: _____

Organism 3: _____

Organism 4: _____



6. Cells are grouped into two categories. Those having a nucleus are called eukaryotic (eu = true, karyotic = kernel). Those lacking a nucleus are called prokaryotic (pro = first).

Decide if organisms 1 to 4 in question 5 are eukaryotic or prokaryotic.

Organism 1: _____

Organism 2: _____

Organism 3: _____

Organism 4: _____

7. Would human cells be prokaryotic or eukaryotic? _____

LICHENS

34

All organisms classified in the same kingdom have some similarities. Thus, lichens, which contain a fungus, have some characteristics in common with other molds. But lichens are unique in that they are a combination of two different organisms, an alga and a fungus. These two organisms exist together in a symbiotic relationship. Symbiosis is the living together in close association of two different organisms.

In lichens, the alga is either a blue green or green species. Through photosynthesis, the alga provides food for the lichen. The alga is surrounded by the mycelium of the fungus, which provides moisture, protection, and possibly some minerals to the lichen. Because both organisms benefit from their association, a lichen is an example of a mutualistic relationship.

In this investigation, you will

- determine the specific lichen type of three lichen samples.
- diagram the macroscopic appearance of three lichen samples.
- observe and diagram the microscopic appearance of a typical lichen.

Materials

microscope	water
glass slide	three lichen samples labeled A, B, and C
coverslip	<i>Cladonia</i> (reindeer moss)
dropper	

Procedure

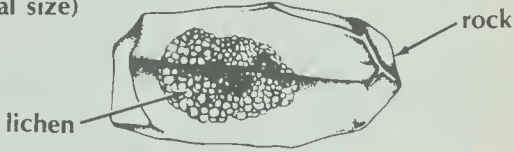
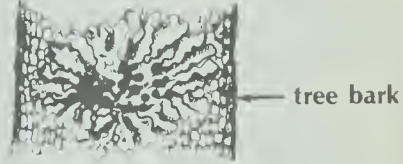

Part A. Lichen Types and Appearance

Lichens are grouped into three different categories or types depending on their growth form and general shape. The three types are described in Table 34-1.

• Examine the lichen samples provided. Each sample is labeled with the letters A, B, or C for identification.

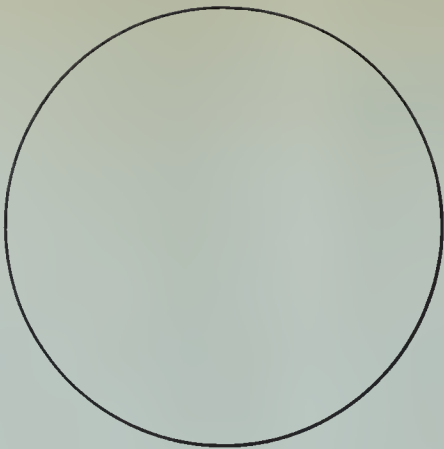
• Using your observations and the information given in Table 34-1, complete Table 34-2.

TABLE 34-1. LICHEN TYPE

LICHEN TYPE	DESCRIPTION	APPEARANCE
crustose	flat or crusty, forms a mat on rocks or bark	(natural size) 
foliose	spreading leaflike lobes, has a papery appearance	(natural size) 
fruticose	stalked vertical growth or branching, may appear hairlike or as branching threads	(2X natural size) 

Part B. Microscopic Appearance of Lichens

- Make a wet mount of a small piece of *Cladonia* (the size of a fingernail). Before adding the coverslip, mash the lichen with the eraser end of a pencil. Add one or two more drops of water if necessary.
- Observe the lichen under low and high powers of your microscope. Look for small round green cells (alga), and long, thin colorless strands (fungus). Diagram and label the parts of the lichen in the space provided.



Cladonia under high power

TABLE 34-2. LICHEN CHARACTERISTICS				
SAMPLE	COLOR	GENERAL DESCRIPTION	DIAGRAM	TYPE
A				
B				
C				

Analysis

1. Define
- (a) lichen. _____
 - (b) symbiosis. _____
 - (c) mutualism. _____
2. How are lichens symbiotic? _____
3. (a) Microscopically, how do the algal and fungal parts of a lichen differ? _____
- (b) Why is the color of the alga important to a lichen? _____
4. Explain how lichens can survive in barren conditions. _____

ALGAL PLANTS

35

Plants are not always large and found living in soil. Many forms are microscopic and live in water. Regardless of their size or where they live, plants all have one thing in common—they are capable of making their own food through the process of photosynthesis. In order to carry out this process they must contain a green pigment called chlorophyll. The plants studied in this investigation may not all appear to be green. However, chlorophyll is present even though it may be hidden by other colored pigments.

In this investigation, you will

- observe three different green algae under the microscope.
- diagram and compare these three green algae to one another.
- observe an example of brown and red algae, comparing them to the green algae samples.

Materials

microscope
glass slide
coverslip
dropper
Ulothrix, preserved
Spirogyra, preserved
Zygnema, preserved
Hydrodictyon, preserved
brown algae, preserved
red algae, preserved

Procedure

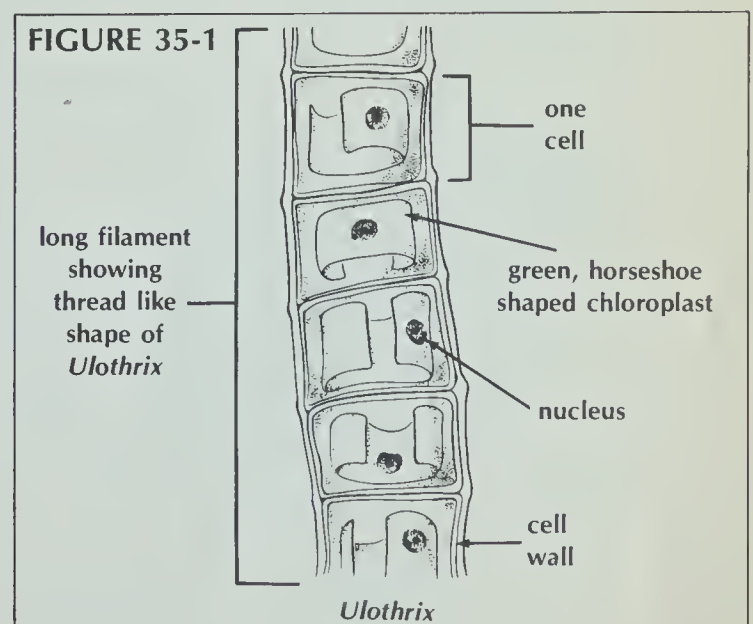
Part A. Green Algae

Ulothrix

- Prepare a wet mount of preserved *Ulothrix* for microscopic viewing.

- Observe this green alga under low and high powers.

- Note the following parts shown in Figure 35-1:
 - green, horseshoe shaped chloroplast
 - nucleus
 - cell wall
 - filament
 - one cell in size.



Spirogyra

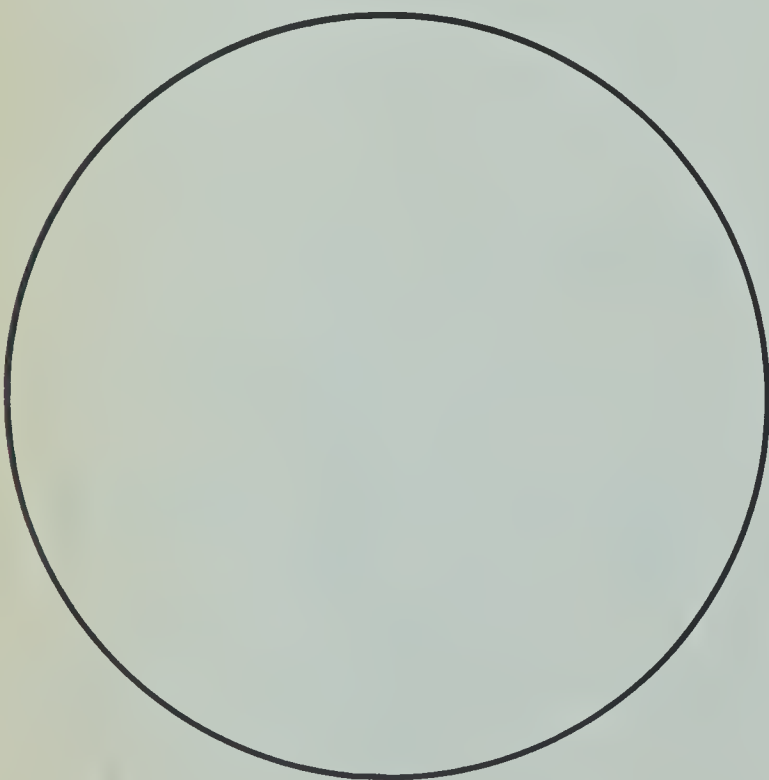
- Prepare a wet mount of preserved *Spirogyra*.
- Observe the green alga under low and high powers.
- Diagram one or two cells of *Spirogyra* in the space provided. Note the shape of its chloroplasts. Use high power when drawing the alga.
- Label these parts on your diagram of *Spirogyra*: *cell wall, green chloroplast, nucleus, single cell*.

1. Describe the shape of *Spirogyra*'s chloroplast.

2. Describe the color of *Spirogyra*'s chloroplast.

3. Describe the shape of the entire alga (for example: threadlike). _____

Spirogyra is a freshwater colonial green algae. It is usually found floating in lakes or ponds. In deep cold springs and pools *Spirogyra* forms enormous green "clouds" several metres in diameter. In shallow warm water, many filaments of *Spirogyra* will grow together to form a thick mat in the water. Each filament of the algae contains many identical cells. There are no specialized cells for carrying out life processes in *Spirogyra*. The chloroplasts in this alga are ribbon-shaped structures which form spirals throughout each cell.



Spirogyra
(high power magnification)

Zygnema

- Prepare a wet mount of preserved *Zygnema*.
- Observe this green alga under low and high powers.
- Diagram one or two cells of *Zygnema* in the space provided. Note the shape of its chloroplast. Use high power when drawing the alga.
- Label these parts on your diagram of *Zygnema*: *cell wall, green chloroplast, nucleus, single cell*.

4. Describe the shape of *Zygnema*'s chloroplast.

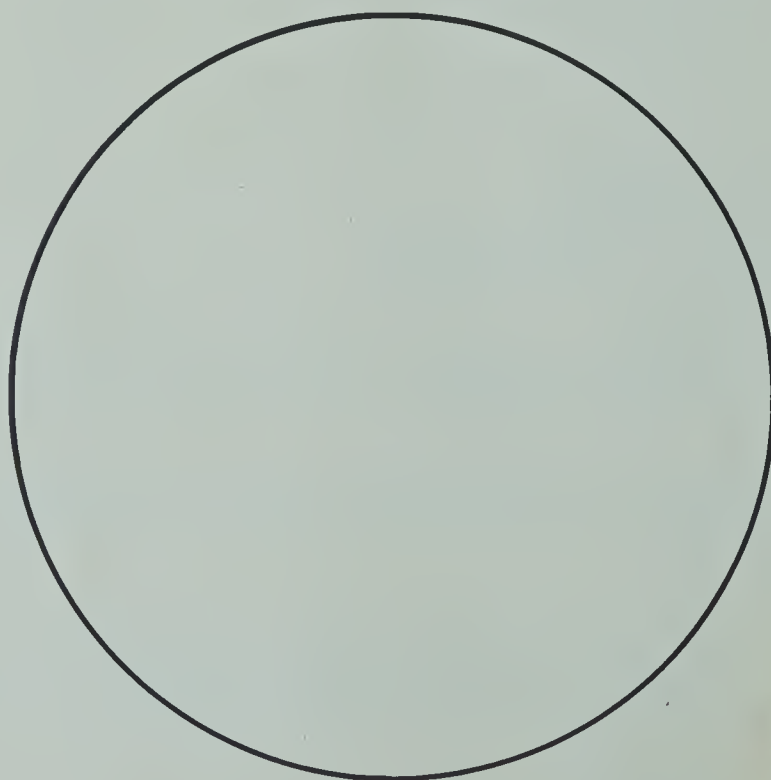
5. Describe the color of *Zygnema*'s chloroplast.

6. Describe the shape of the entire alga. _____

Zygnema forms unbranched filaments in freshwater environments. *Zygnema* grows best in "hard" water lakes or in shallow ponds in which there is a high concentration of organic material. ("Hard" water has a higher concentration of iron, magnesium, calcium, and other minerals than does "soft" water.) The filaments of this algae sometimes form pale green, cottony masses.

Hydrodictyon

- Prepare a wet mount of preserved *Hydrodictyon*.



Zygnema
(high power magnification)

• Observe this green alga under low and high powers.

• Diagram one or two cells of *Hydrodictyon* in the space provided. Note its overall shape and the shape of its chloroplast. Use high power when drawing the alga.

• Label these parts on your diagram of *Hydrodictyon*: cell wall, green chloroplast, nucleus, single cell.

7. Describe the shape of *Hydrodictyon*'s chloroplast. _____

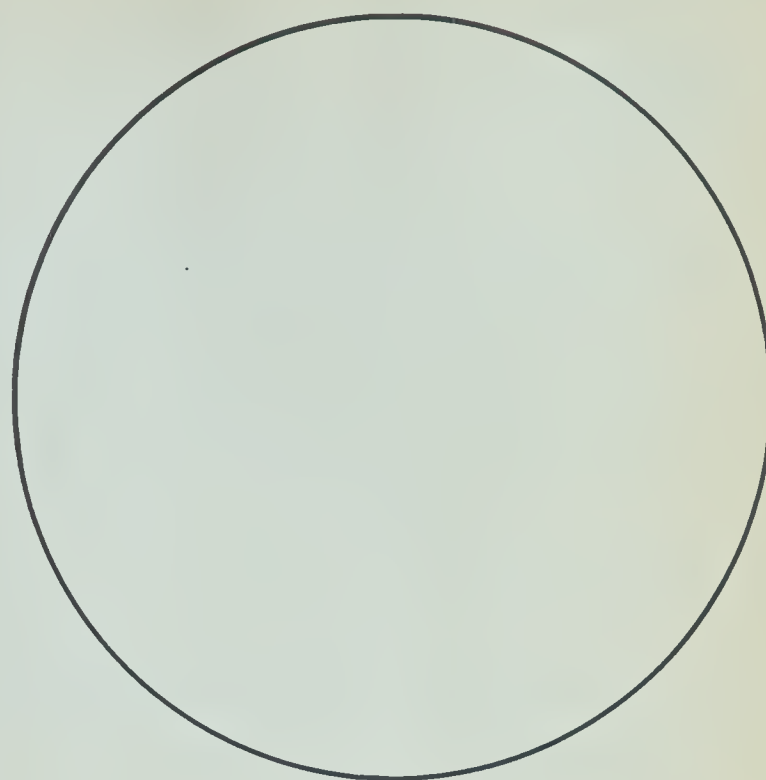
8. Describe the color of *Hydrodictyon*'s chloroplast. _____

9. Describe the shape of the entire alga. _____

Hydrodictyon is a colonial algae usually found in lakes and slow-moving streams. The cells of *Hydrodictyon* join at their ends to form "nets" with five or six sides. These "nets" join to form a sleevelike shape that sometimes reaches up to one-half metre in length. These sleeves can form thick floating mats which sometimes unbalance the biological conditions of the environment. *Hydrodictyon*, like *Zygnema*, grows best in "hard" water.

Part B. Brown and Red Algae

• If available, observe samples of brown and red algae. Brown and red algae are macroscopic,



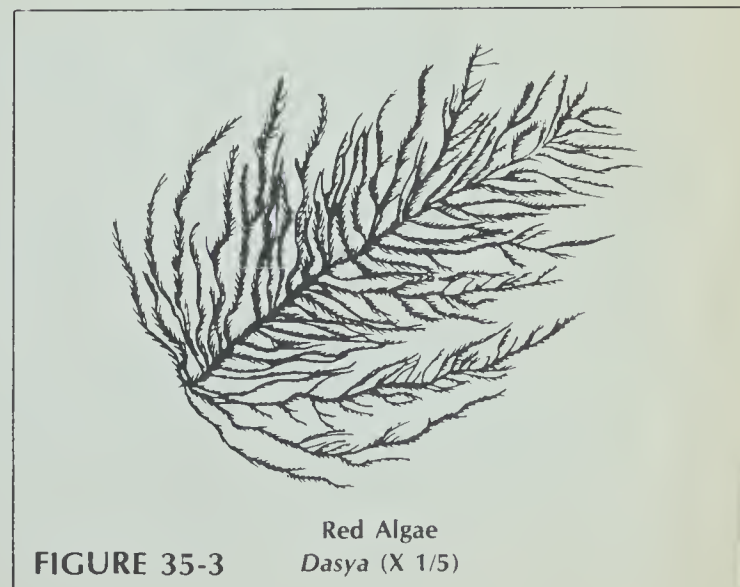
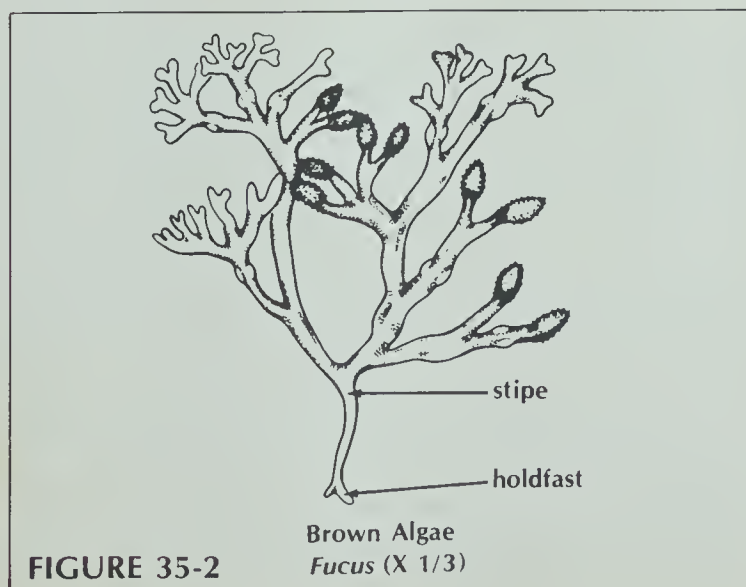
Hydrodictyon
(high power magnification)

meaning they are large enough to be seen without a microscope.

• If samples are not available, study Figures 35-2 and 35-3.

Most brown and red algae have a marine habitat. Marine organisms live in sea or salt water. All the algae studied in Part A are freshwater algae that live in lakes or ponds.

Most brown and red algae are multicellular and all have nuclei within their cells. They often are found clinging to rocks along the ocean shores by a special structure called a holdfast.



Analysis

1. Define the following terms:

(a) photosynthesis _____

(b) chlorophyll _____

(c) marine _____

(d) macroscopic _____

2. Give an example of each of the following types of algal plants:

(a) green algae _____

(b) brown algae _____

(c) red algae _____

3. List three ways in which the green algae studied are all alike. _____

4. List two ways that the green algae studied are different. _____

5. List two ways that brown or red algae differ from the green algae studied. _____

6. Complete the following chart.

	<i>SPIROGYRA</i>	<i>FUCUS</i>	<i>DASYA</i>
Food getting process			
Chlorophyll present?			
Major color			
Nucleus in each cell?			
Macroscopic or Microscopic			
Habitat			

LIVERWORTS, MOSSES, AND FERNS

36

Plants may be divided into two main groups, plants that have true roots, stems, and leaves and plants that do not. One way to tell if a plant has these structures is to look for conductive tissues within the plant. Conductive tissues carry water, food, and minerals rapidly throughout the plant. In order to have true roots, stems, and leaves, a plant must have conductive tissue. These plants are called vascular plants. Plants without conductive tissue often have structures which function like roots, stems, and leaves, but transport within the plants is accomplished by diffusion, not conductive tissue. These plants are called nonvascular plants.

In this investigation, you will

- (a) examine two examples of nonvascular plants—liverworts and mosses.
- (b) examine one vascular plant—a fern.
- (c) study the structure and function of the special parts of these three plants.

Materials

microscope
glass slide
coverslip
glycerine
hand lens (or binocular microscope)
razor blade (single edge)
liverwort (preserved or living)
moss (preserved or living)
fern (preserved or living)

beaker—500 mL
paper towel
scissors
rubber band (or twist tie)
water
graduated cylinder
sphagnum moss
cheese cloth
metric ruler

Procedure

Part A. Liverworts

- Examine a liverwort.

- Note in particular its simple structure. Liverworts have no true roots, stems, or leaves. Instead, they have

- (a) rootlike parts called rhizoids. Rhizoids are located on the underside of the plant and resemble tiny threads.
- (b) a leaflike part called the thallus. The thallus is the main body of the plant. No stemlike part is present in liverworts.

- Locate the *thallus* and *rhizoids* on your liverworts.

- Label these two structures on Figure 36-1.

- Use a hand lens to locate the many tiny dotlike pores or holes on the upper surface of the thallus. Label the *pores* on Figure 36-1.

FIGURE 36-1

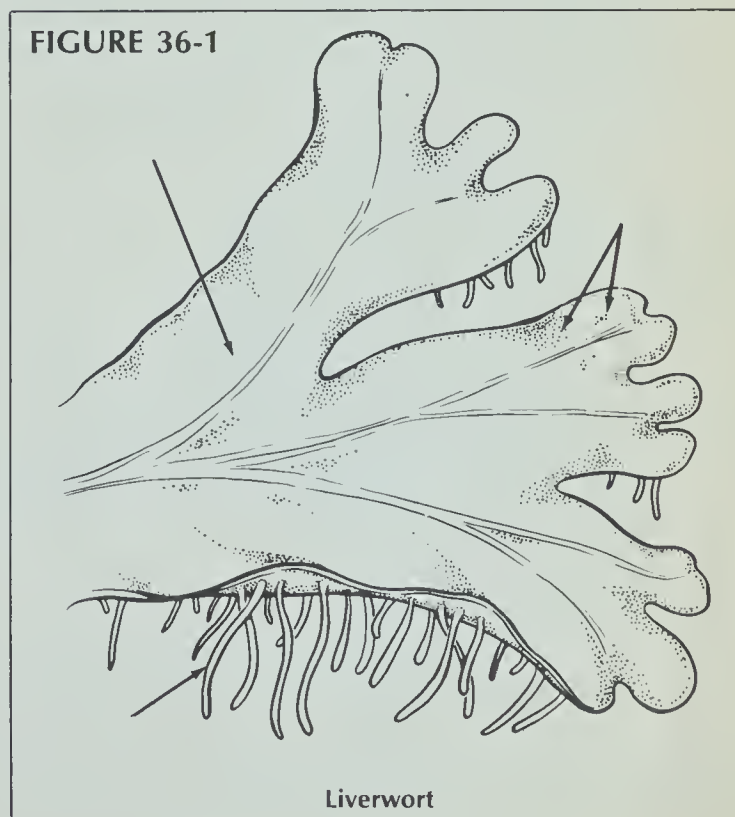
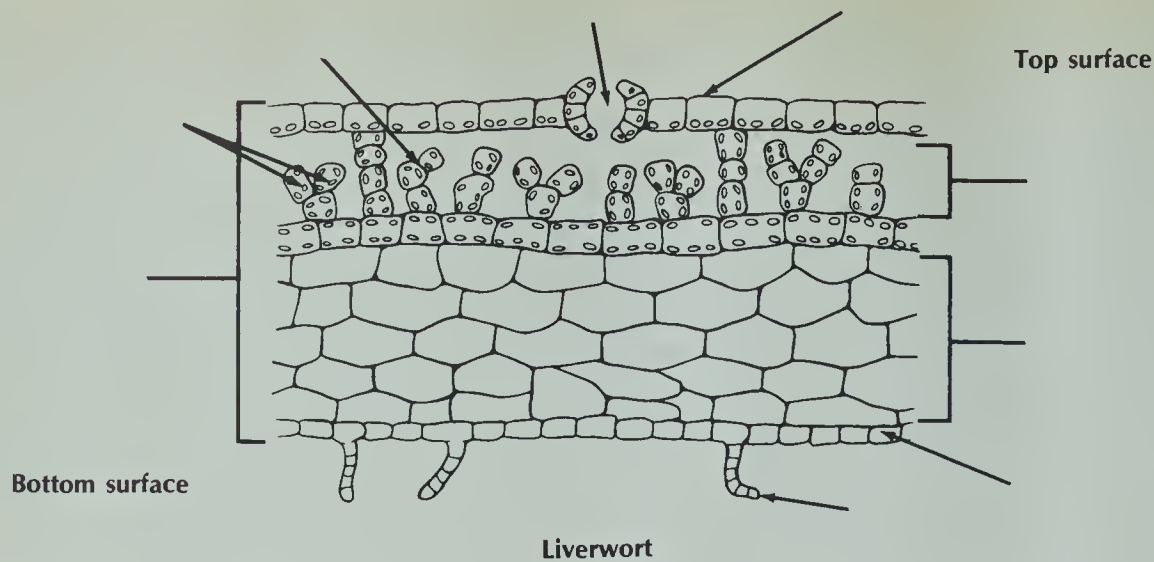


FIGURE 36-2



● Figure 36-2 shows a slice through a liverwort thallus. Identify and label the following parts or areas of the thallus on Figure 36-2.

- Thallus*—entire body of liverwort.
- Rhizoids*—threadlike structures on bottom surface.
- Lower epidermis*—single layer of cells along bottom surface of thallus.
- Chloroplasts*—small dotlike structures within certain cells.
- Pore*—small opening on top surface of thallus.
- Air chamber*—space between cell layers just below top surface.
- Columnar cells*—cells containing chloroplasts, arranged in columns of four or five cells.
- Storage cells*—large cells near the bottom of the thallus which contain no chloroplasts.
- Upper epidermis*—cells only one layer thick across the upper surface of the thallus. These cells contain chloroplasts.

Part B. Mosses

● Examine a moss plant.

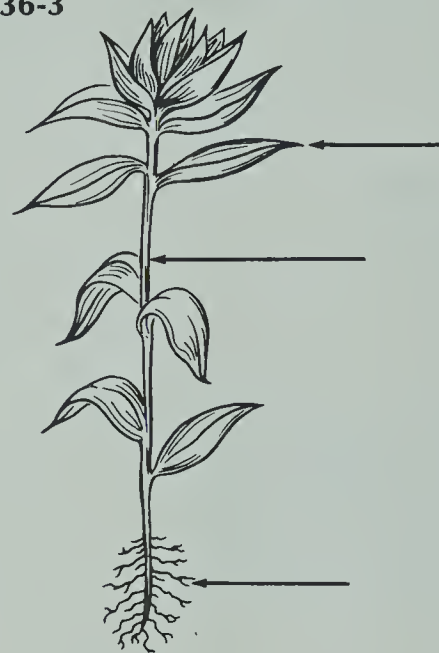
● Like liverworts, moss plants have no true roots, stems, or leaves. Instead, moss plants have

- rootlike structures called rhizoids. Rhizoids are located at the bottom of the plant and function as roots.
- a stemlike structure.
- a leaflike structure.

● Label these three moss structures on Figure 36-3.

● Remove one leaflike part. Prepare a wet mount and observe it under low power.

FIGURE 36-3



1. If the “leaf” is from a living plant, are chloroplasts present within its cells? _____

2. How many cells thick is the “leaf”? _____

Some moss plants have special characteristics. Certain moss plants such as sphagnum moss can absorb large amounts of water. To illustrate this idea, do the following:

● *Step 1.* Put 200 mL of water into a 500-mL beaker.

● *Step 2.* Cut a square of cheesecloth that measures 20 cm × 20 cm. **CAUTION:** Always be careful with scissors. Place a clump of sphagnum moss the size of your fist onto the cheesecloth. Gather the cheesecloth around the moss, forming a ball. Secure the cheesecloth at the top with a rubber band or twist tie.

• **Step 3.** Place the sphagnum moss ball into the beaker of water. Wait 15 minutes.

• **Step 4.** After 15 minutes, remove the sphagnum moss ball from the beaker. Measure the volume of water remaining in the beaker. Record this amount in Table 36-1 and complete the rest of Table 36-1.

TABLE 36-1. SPHAGNUM MOSS		
A	B	C
Original amount of water in beaker	Amount of water left in beaker after 15 minutes	Amount of water absorbed by sphagnum (A-B)
200 mL		

Part C. Ferns

• Examine a fern (or just the leaves of a fern).

• Note in particular the following structures. (Use Figure 36-4 if the entire plant is not available.)

- true roots*—located below ground
- true stem*—usually located below ground, thick, lies in a horizontal position. This underground stem is called a rhizome (not rhizoid).
- true leaves*—large green structures, often lacy in appearance and sometimes called fronds

• Label these three parts on Figure 36-4.

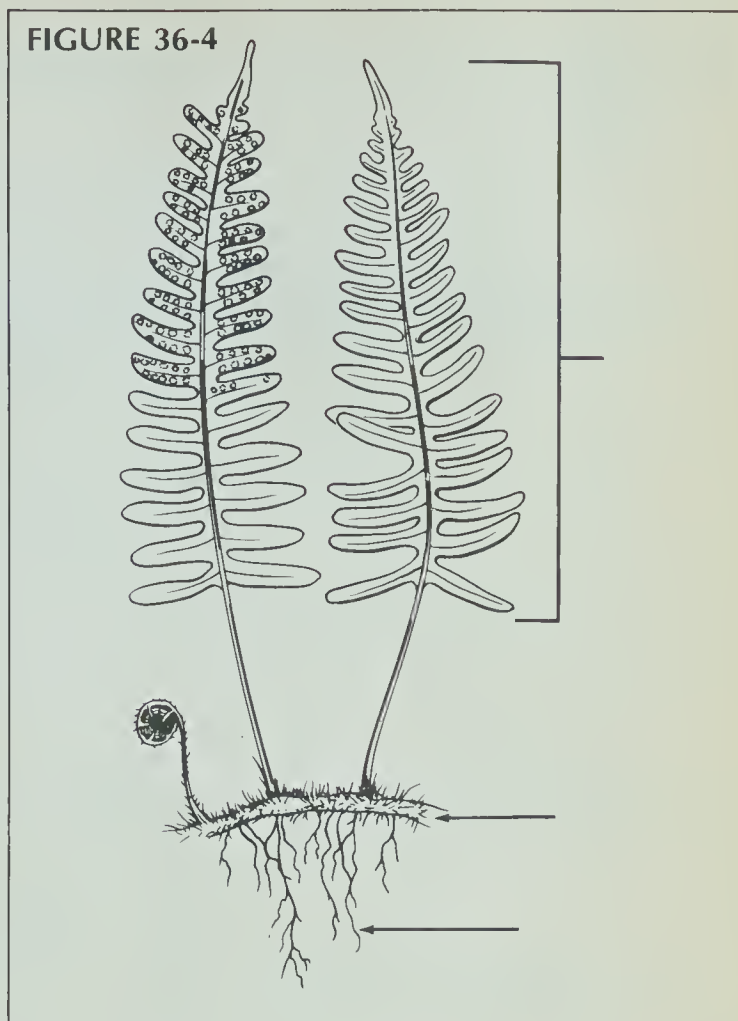
• Note the many tiny dotlike structures on the fronds. These are reproductive parts and are called sori (singular sorus).

• Remove one sorus with a razor blade and prepare a wet mount. **CAUTION: Razor blade is sharp. Cut away from your fingers.** Observe the sorus under low power. You should observe a number of objects that resemble Figure 36-5. Each of these objects is called a sporangium.

• Remove the wet mount from your slide. Blot the wet mount dry with paper toweling. Add a drop of glycerine to the sorus. Add a coverslip and observe again under low power for several minutes.

3. What happened to the sporangium? _____

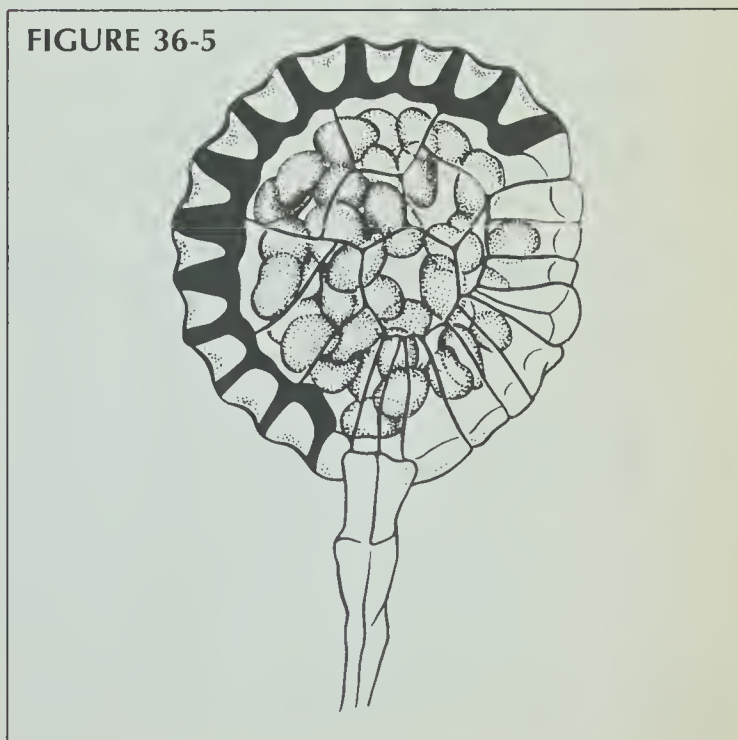
FIGURE 36-4



4. Describe the structures which were released from each sporangium. _____

Release of these structures (spores) occurs in nature. If a spore lands on moist soil, it may continue the life cycle of the fern plant.

FIGURE 36-5



Analysis

1. Define the following terms:

(a) true roots, stems, and leaves (see introduction) _____

(b) rootlike, stemlike, or leaflike parts _____

(c) thallus _____

(d) rhizoid _____

(e) rhizome _____

(f) sorus _____

(g) sporangium _____

2. Compare the three plant types studied by completing this table.

	LIVERWORT	MOSS	FERN
Size of plant (small or large)			
Color			
True root present?			
True stem present?			
True leaves present?			
Conducting tissue present?			
Rhizoids present?			
Rhizome present?			
Thallus present?			

3. Gardeners often add sphagnum moss to soil. Based on your findings in Part B, why is this a good practice? _____

4. Most liverworts and moss plants are found growing in moist areas on forest floors. Why might these plants be restricted to growing only in moist places? _____

A SURVEY OF SOME ANIMAL PHYLA

37

The animal kingdom is divided into a number of groups called phyla. Each phylum contains animals which show certain common traits or characteristics. These traits are important when studying the animal phyla. The traits allow biologists to fit together a system of classification which shows progressive change from simple to complex life forms.

In this investigation, you will

- examine the parts or organs of five animals that represent four different phyla.
- note the major phylum traits of these animals.
- compare traits of each phylum to the other phyla.

Materials

Grantia sponge (preserved)
Spongia sponge (dry)
 bleach
 droppers—2
 glass slide

coverslip
 microscope
Hydra, prepared slide
Planaria, prepared slide
Ascaris (preserved)

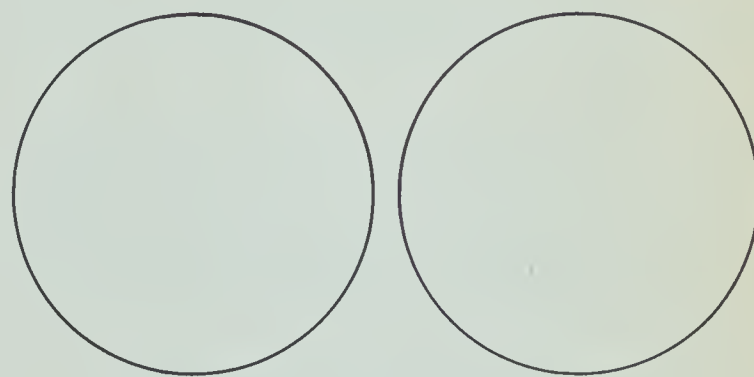
Procedure

Part A. Phylum Porifera

- Observe and compare two different sponge types, *Grantia* and *Spongia*. *Grantia* lives in fresh water. *Spongia* lives in salt water.
- Note the many pores present on the bodies of both sponges. These pores allow food to enter the animal. Sponges have only two body layers.

Sponges have a hard support system that can be observed under the microscope.

- Add two drops of bleach to a slide. **CAUTION:** If spillage occurs, rinse with water.
- Add a small piece (fingernail size) of *Grantia* to the bleach.
- Add a coverslip. Observe *Grantia* using low power.
- Diagram what you see in the space provided. The structures you see are called spicules. *Grantia* spicules are composed of calcium carbonate.
- Observe the hard support system of *Spongia*.
- Add two drops of water to a glass slide.



Spicules of
Grantia

Spicules of
Spongia

- Pull off as small a piece of *Spongia* as possible and place it in the water.
- Add a coverslip. Observe using low power.
- Diagram what you see in the space provided. The spicules you see are composed of spongin. *Spongia* spongin is protein fibers.

Part B. Phylum Coelenterata

An example of this phylum is an animal called *Hydra*. *Hydra* is found in fresh water, although most coelenterates are marine organisms.

Figure 37-1 shows a greatly enlarged *Hydra* sliced open lengthwise. The animal has only two body layers.

● Label the structures and areas of *Hydra* listed below on Figure 37-1.

- (a) *intestine cavity*—hollow space inside the animal.
- (b) *mouth*—opening to outside at top of animal. Connects environment to intestine cavity and serves as an anus and a food opening.
- (c) *tentacles*—armlike structures surrounding mouth (usually six tentacles are present, but only five are shown on the diagram.)
- (d) *ectoderm layer*—layer of cells forming the outside covering of the animal.
- (e) *endoderm layer*—a layer of cells forming the inside covering of the animal.
- (f) *stinging capsules*—special cells in the ectoderm layer of the tentacles. Each cell has a sharp needlelike point sticking out from it. These short, dartlike structures sting small fish.
- (g) *testes*—protruding area of ectoderm. Many small sperm cells are contained within.
- (h) *ovary*—area of ectoderm that “bulges out.” Contains only a few large eggs.
- (i) *body*—region of animal below tentacles. Makes up most of animal.

● Examine a prepared slide of *Hydra*. NOTE: Use low power.

● Diagram what you see in the space provided. It will be necessary to move the slide in order to see the entire animal. Label these parts: *tentacles*, *body*, *mouth* (or its expected location if not actually seen).

● Use high power to study one tentacle.

● Diagram several stinging cells in the space provided.

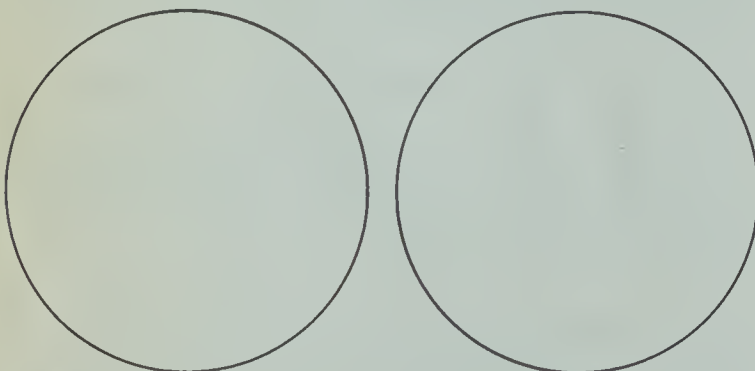
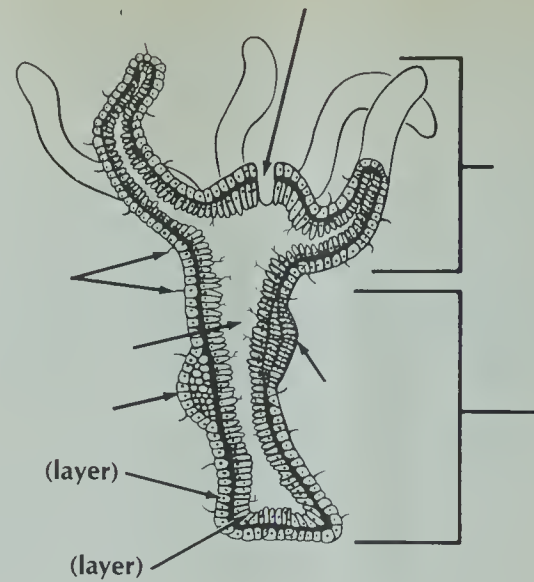


FIGURE 37-1



Part C. Phylum Platyhelminthes

Organisms in phylum Platyhelminthes are commonly called flatworms, giving you an idea as to the type and shape of these animals. Worms in this phylum have three body layers. Coelenterates have only two, ectoderm and endoderm.

Planaria is a flatworm found living in streams. We shall use it as a representative animal for this phylum.

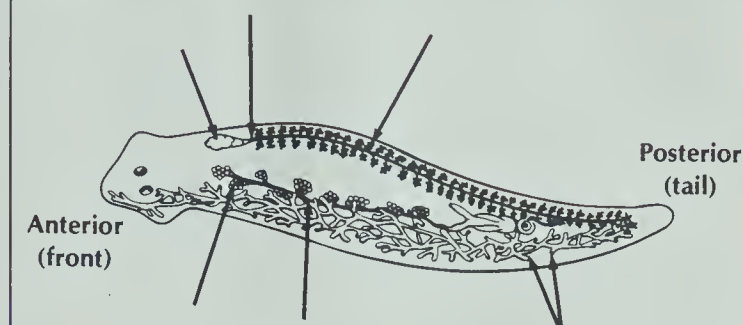
● Label those parts listed below on Figure 37-2. The figure is a “see through” diagram of the animal.

- (a) *eyespots*—two, near anterior end of animal.
- (b) *brain*—located between eye spots, small.
- (c) *nerve cords*—two long structures running full length along each side connected at anterior end to brain.
- (d) *intestine*—largest organ in animal; has three main sections, one toward anterior end that branches into two smaller sections toward posterior end.

FIGURE 37-2



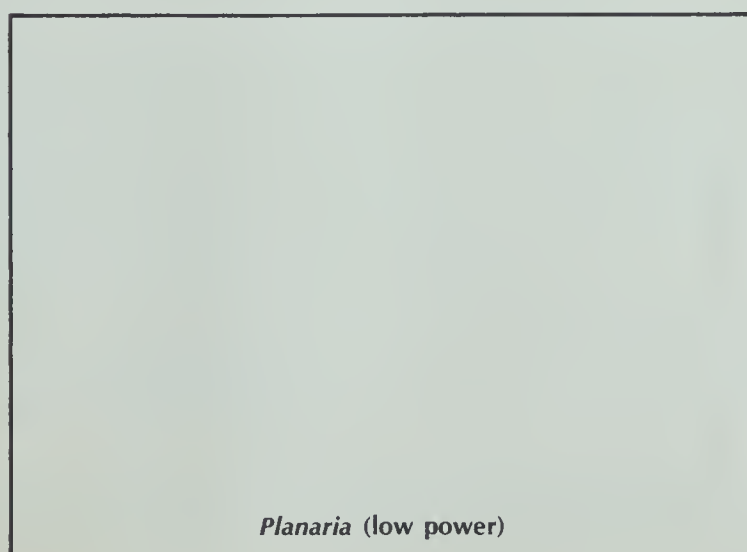
- (e) *pharynx*—thick, tubelike part connected to intestine; about in middle of animal, also has an opening at posterior end.
- (f) *mouth*—opening at posterior end of pharynx, also serves as anus.

FIGURE 37-3

- Label those parts listed below in Figure 37-3. This figure is also a "see through" diagram.

- (a) *ovary*—found on both sides of the animal but shown only on the top in the diagram; round structure at anterior end.
- (b) *oviduct*—long tube connected to ovary, runs entire length of animal.
- (c) *yolk glands*—connected to oviduct; looks like clusters of grapes.
- (d) *testis*—found on both sides, but pictured only on the bottom.
- (e) *sperm duct*—long tube connected to testis
- (f) *excretory organ*—found on both sides, but pictured only on bottom; a weblike pattern of tubes that end in fingerlike projections.

- Observe a prepared slide of *Planaria* under low power.



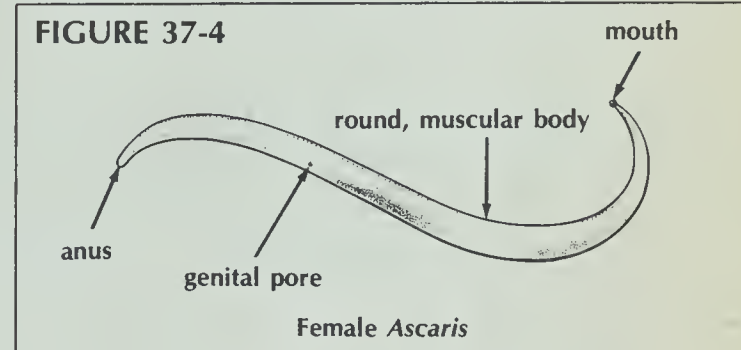
- Diagram what you see in the space provided. Label those parts which you can see. NOTE: It will be necessary to move the slide while observing so that all parts of the animal can be viewed.

Part D. Phylum Nematoda

The nematode phylum consists of worm-shaped animals that have round bodies. Like the platyhelminthes, these animals have three body layers.

Ascaris is to be used as a representative animal for this phylum. It is a parasitic worm, meaning it lives within the body of some other animal such as a horse, pig, or human.

- Observe the external features of a female *Ascaris* in Figure 37-4. The male worm is nearly identical in appearance, but only half the size of the female.

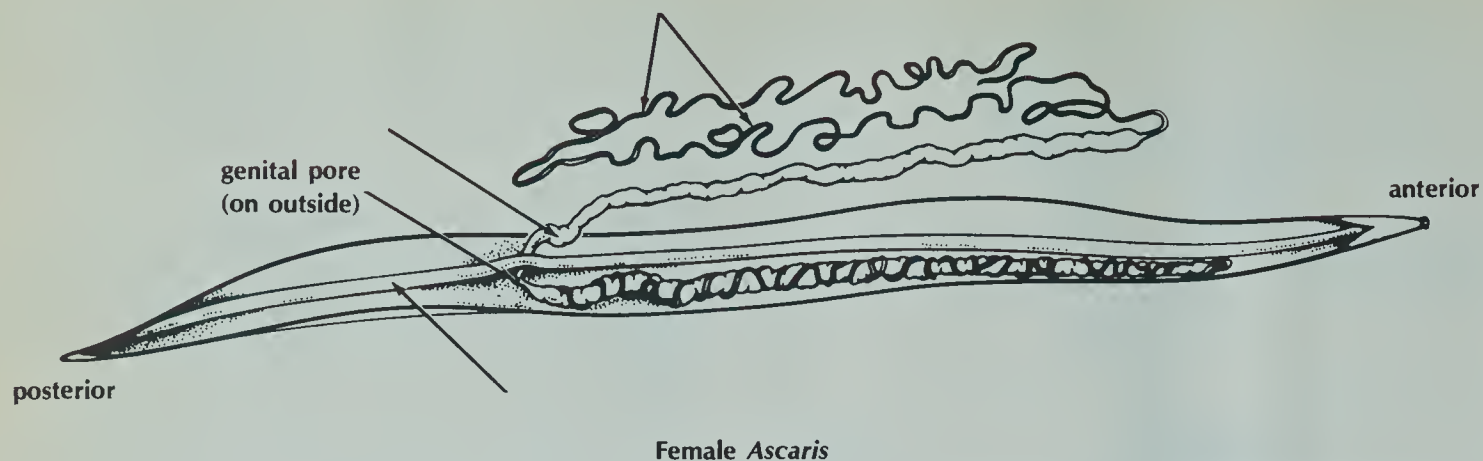
FIGURE 37-4

- The internal features of a female *Ascaris* are shown in Figure 37-5. Identify and label the following parts.

- (a) *intestine*—long tube which extends from mouth to anus. NOTE: This is the first group of animals so far to have two separate openings to the intestine, a mouth and anus. Food is taken in through the mouth. Wastes pass out through the anus.
- (b) *uterus*—two are present in females; thick, round organs that lie alongside the intestine. One has been lifted out of the body. Both uteri join toward the anterior of the animal and discharge eggs through the genital pore.
- (c) *ovary and oviduct*—connected structures present on both sides of the animal. One has been lifted out of the body and looks like thin, spaghetti-like tubes.

Two systems which are present in *Ascaris* but are difficult to observe are the excretory and nervous systems. Both consist of long, stringlike structures that run the entire length of the animal and are embedded inside the thick body muscle.

FIGURE 37-5



Female *Ascaris*

Analysis

1. Name the kingdom and phylum to which each of the following belong.

(a) sponges _____

(b) *Hydra* _____

(c) *Planaria* _____

(d) *Ascaris* _____

2. Complete the chart below by listing the organs present in each system of each animal.

	NERVOUS	REPRODUCTIVE	EXCRETORY	DIGESTIVE
sponges				
<i>Hydra</i>				
<i>Planaria</i>				
<i>Ascaris</i>				

EARTHWORM ANATOMY

38

Earthworms (*Lumbricus terrestris*) are representative animals of phylum Annelida. Examining external and internal structures of an earthworm will reveal some major annelid characteristics.

Lumbricus is an excellent animal for study because of its body organization. An earthworm is a segmented animal. Its body plan consists of many rings (annellus means "ring" in Latin). Each segment, or ring, of an earthworm is numbered in sequence from anterior to posterior end. Organs can be located by finding the particular segments they are known to be in. An earthworm "map" lists the location of each organ or structure by segment number (Table 38-1).

In this investigation, you will

- identify organs of the major systems of an earthworm by using an earthworm "map."
- label the organs of an earthworm on a diagram.
- determine the major phylum traits for earthworms based on your observations while dissecting this animal.

Materials

preserved earthworm
straight pins
razor blade (single-edge) or scalpel
dissecting pan
hand lens
scissors
colored pencils (optional)

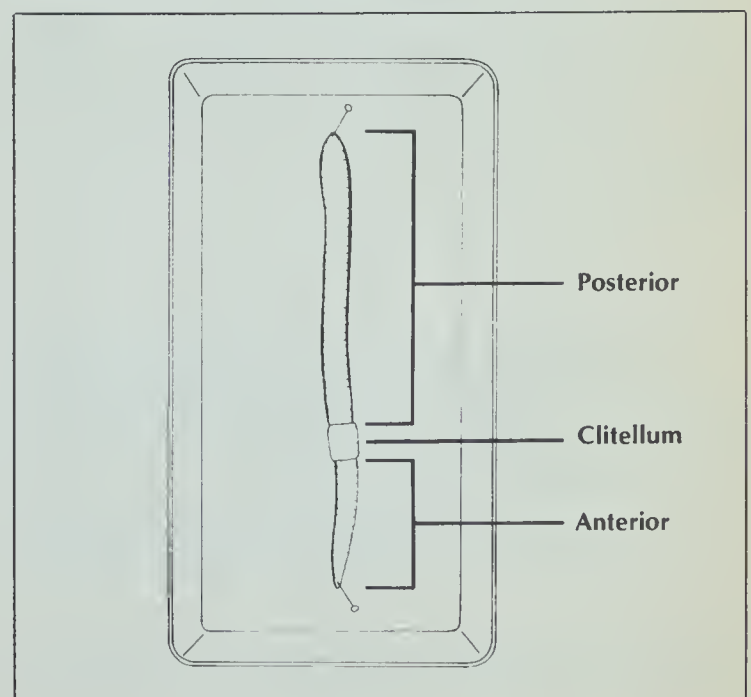
Procedure

- Identify the anterior (head), posterior (tail), dorsal (top), and ventral (bottom) sides of a preserved earthworm.

A bandlike structure, the clitellum, separates the body into two unequal lengths. The shorter section (about $\frac{1}{3}$ of the total body length) is the anterior portion. The longer section is the posterior portion. The dorsal surface is darker than the ventral surface and rounded toward the anterior end. The ventral surface is flat.

- Stretch your animal out with the dorsal side up in a dissection pan.
- Pin the earthworm to the pan with straight pins. Use one pin at each end of the worm (Figure 38-1).

FIGURE 38-1

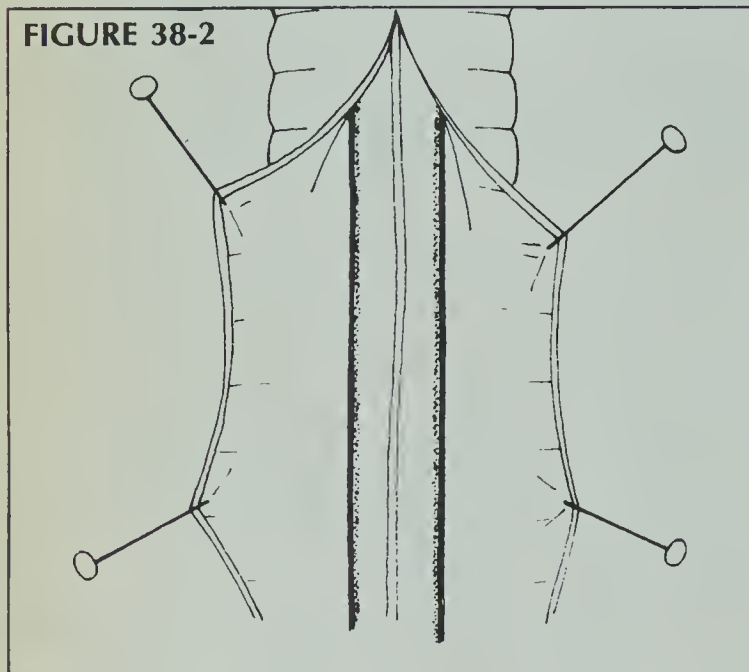


- Cut through the skin and muscle of your worm with a razor blade. **CAUTION: Blade is sharp. Cut away from your fingers.** Start by cutting at the posterior end along the dorsal surface. **NOTE: An earthworm's skin and muscle are extremely thin. A very shallow cut is all that is needed.**

- Spread the edges apart by carefully cutting through thin membranes (septa) on the inside of the worm. These septa are continuous with each groove on the worm's outside surface.

- Pin the skin and muscle to the dissection pan as you spread these tissues apart. Slant the pins out at an angle (Figure 38-2).

FIGURE 38-2



- Continue to carefully cut and pin your animal until you reach the anterior end.

- After you have completely opened your earthworm, identify the internal organs by using the earthworm "map" and the following explanations. The organs of each system are listed on the "map" beside the number of the segment in which they are located. If an organ is in more than one segment, the segments that it is in are included in brackets.

Digestive System

The digestive system is a tube extending from segment one to the last segment. Organs of this system are shaded in Figure 38-4 to help you identify them in Figure 38-3.

- Use the "map" on page 150 to identify each specific part.

- Label the organs of the digestive system on Figure 38-3 and color them green.

FIGURE 38-3

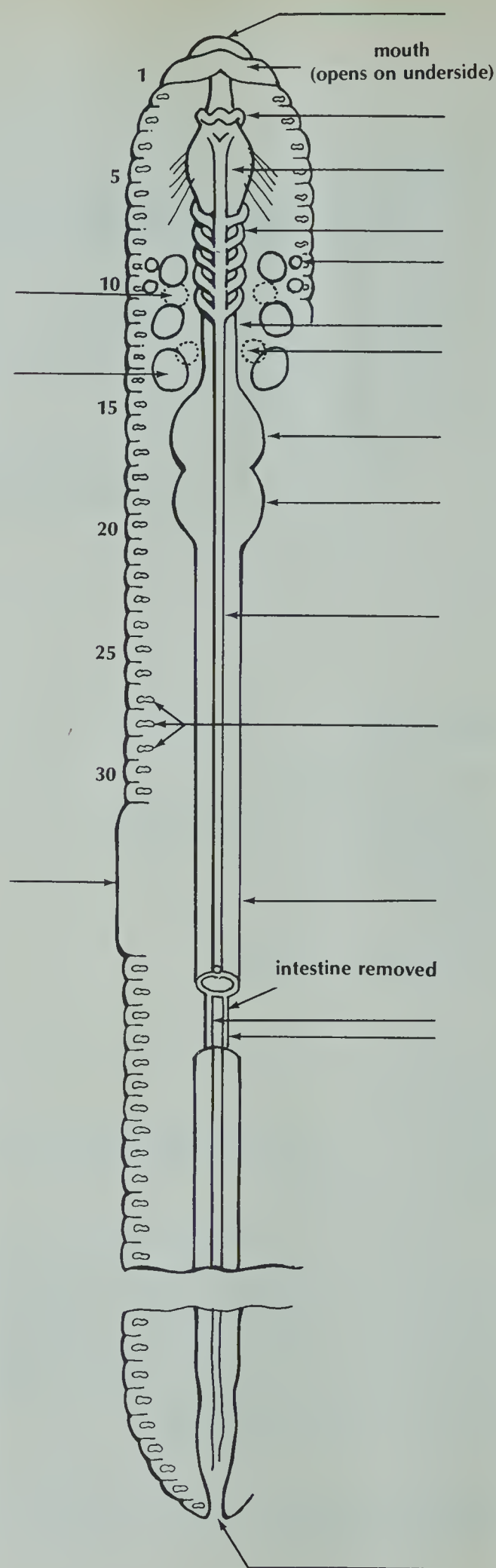


FIGURE 38-4

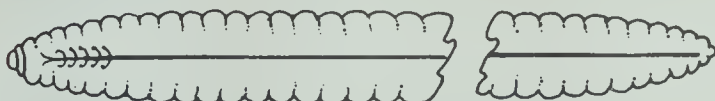


Circulatory System

A thin blood vessel extends the entire length of an earthworm. It is located above the digestive organs and is called the dorsal blood vessel. A second vessel, the ventral blood vessel, also extends the entire length of the worm. However, it is below the digestive organs and not visible unless part of the intestine is removed. The ventral blood vessel is the thinner of two strands under the intestine. A series of five "hearts" connect the dorsal and ventral blood vessels. The "hearts" surround the esophagus.

Organs of this system are diagrammed in Figure 38-5 to help you identify them in Figure 38-3.

FIGURE 38-5



- Use the "map" on page 150 to identify each specific part.
- Label the organs of the circulatory system on Figure 38-3 and color them red.

Reproductive System

The reproductive system consists of seminal vesicles, seminal receptacles, ovaries and testes, and the clitellum. The seminal vesicles are three pairs of saclike structures along the esophagus. Two very small almost dotlike structures, on each side near the seminal vesicles, are the seminal receptacles. Ovaries and testes are present in your worm but are difficult to observe. They are shown in Figure 38-3 with dotted lines. The clitellum produces a mucous slime tube during mating.

The reproductive system also includes two sets of pores visible on the exterior of the worm. Segment 14 has a pair of female pores and segment 15 has a pair of male pores.

Organs of this system are shaded in Figure 38-6 to help you identify them in Figure 38-3.

FIGURE 38-6



- Use the "map" on page 150 to identify each specific part.
- Label the organs of the reproductive system on Figure 38-3 and color them yellow.

Nervous System

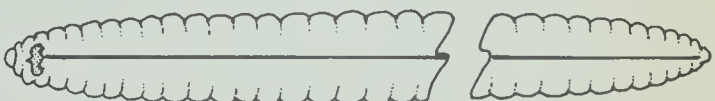
A "brain" (ganglion mass) is a small mass of white tissue in segment 3. It may be destroyed when dissecting a worm. The ventral nerve cord is seen as a white "thread" extending along the worm's ventral surface from segment 3 to the last segment.

Because of its ventral location, the nerve cord cannot be seen well except where organs have been removed.

- Remove part of the intestine to see the nerve cord beneath.

Organs of this system are shaded in Figure 38-7 to help you identify them in Figure 38-3.

FIGURE 38-7



- Label the organs of the nervous system on Figure 38-3 and color them blue.

Excretory System

The excretory system consists of paired organs called nephridia. These are small organs against the lateral (side) walls of the worm. You may need a hand lens to see them. They are present in almost every segment.

Organs of this system are shaded in Figure 38-8 to help you identify them in Figure 38-3.

TABLE 38-1. EARTHWORM "MAP" OF ORGANS

SEGMENT	DIGESTIVE SYSTEM	CIRCULATORY SYSTEM	REPRODUCTIVE SYSTEM	NERVOUS SYSTEM	EXCRETORY SYSTEM
Prostomium					
1	} Mouth				
2					
3	} Pharynx			} Brain	} Nephridia
4					} Nephridia
5					} Nephridia
6					} Nephridia
7	} Esophagus	} Heart			} Nephridia
8		} Heart			} Nephridia
9		} Heart			} Nephridia
10		} Heart	} Testes		} Nephridia
11		} Heart	} Seminal receptacle	} Seminal vesicle	} Nephridia
12					
13			} Ovaries	} Seminal vesicle	} Nephridia
14					
15	} Crop				} Nephridia
16					} Nephridia
17					} Nephridia
18	} Gizzard	Dorsal (and ventral) blood vessel		Ventral nerve cord	} Nephridia
19					} Nephridia
20					} Nephridia
21	} Intestine				} Nephridia
22					} Nephridia
23					} Nephridia
24					} Nephridia
25					} Nephridia
26					} Nephridia
27					} Nephridia
28					} Nephridia
29					} Nephridia
30					} Nephridia
31					} Nephridia
32			} Clitellum		} Nephridia
33					} Nephridia
34					} Nephridia
35					} Nephridia
36					} Nephridia
37					} Nephridia
110					} Nephridia
111					} Nephridia
Last Segment	} Anus				

FIGURE 38-8



- Label the organs of the excretory system on Figure 38-3 and color them orange.

External Structures

Besides the male and female pores, other external structures are the prostomium and setae. The prostomium is like an upper lip. It is attached to the first segment and is above the mouth. It appears to be the first segment but is not a true segment. Setae are groups of tiny bristles which project from most of the segments. They may not be visible, but they can be felt by rubbing your finger along the side of the worm.

- Complete Table 38-2 summarizing annelid characteristics while observing your worm. Check the characteristics that describe earthworms.

TABLE 38-2. CHARACTERISTICS OF ANNELIDA

Body segmented	
Hermaphrodites‡	
Separate sexes	
Digestive system present	
Respiratory system present*	
Appendages present†	
Excretory system present	
Nervous system present	
Reproductive system present	

‡ both sexes in one organism

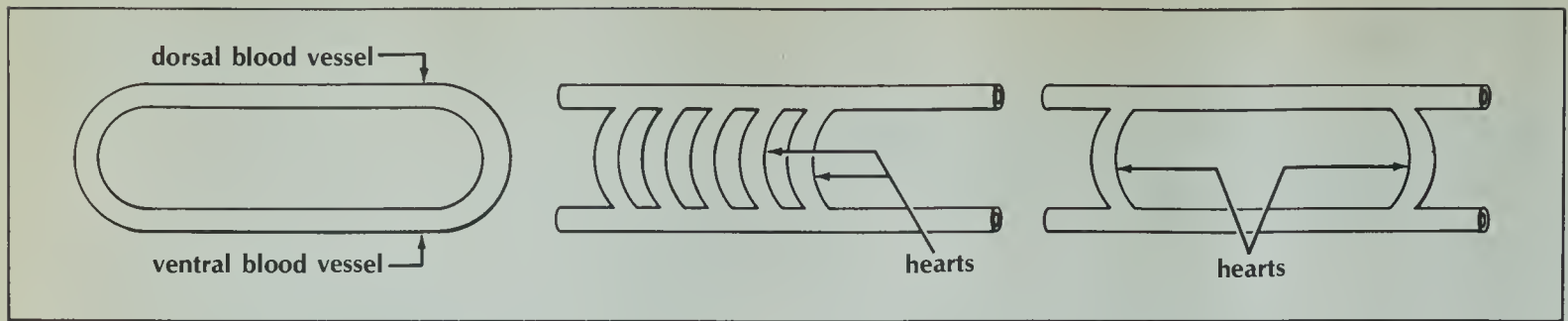
* lungs or gills for gas exchange

† arms or legs

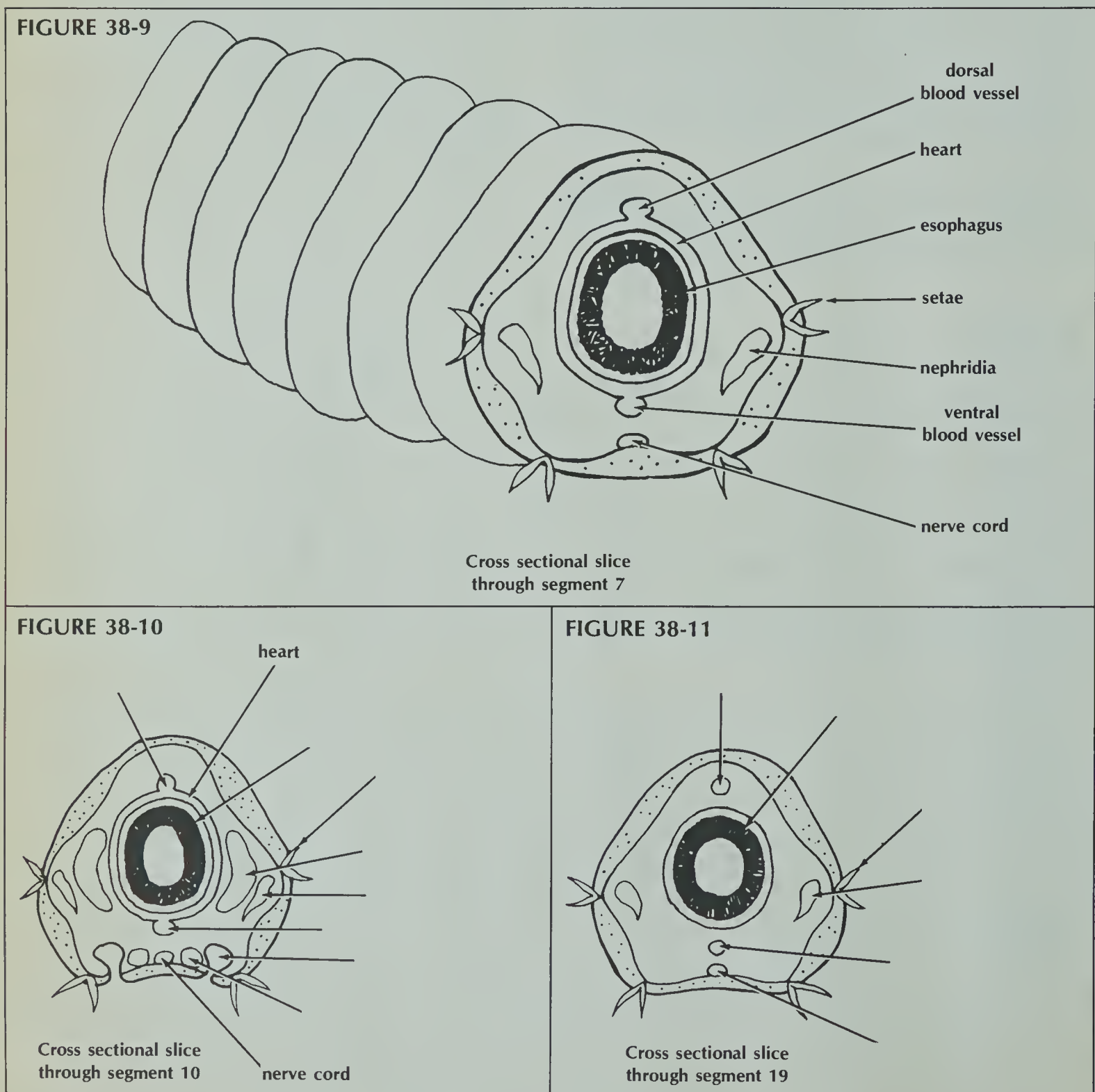
Analysis

- To which phylum does the earthworm belong? _____
 - What is the meaning of this phylum name? _____
- What is the scientific name for an earthworm? _____
 - To what genus do earthworms belong? _____
 - To what species do earthworms belong? _____
- Define the following terms:
 - segmented _____
 - external _____
 - anterior _____
 - internal _____
 - posterior _____
 - dorsal _____
 - ventral _____
 - lateral _____

4. Circle the diagram which best shows a side view of the earthworm's circulatory system.



5. Figure 38-9 is a cross sectional slice through an earthworm at exactly segment 7. Those organs which appear in segment 7 have been labeled for you. Label Figure 38-10 and 38-11 in the same way. Use the map on page 150 as a guide. [HINT: To label segment 10, place a straight edge across the map on page 150 at segment 10. All parts or lines which appear along the straight edge must be included in the cross section diagram. (Two parts are labeled for you.)] Do the same for segment 19.]



ARTHROPODS

39

All the animals in a specific phylum have many similar traits. An examination of representative animals of Phylum Arthropoda would reveal certain similar traits. A list of these traits would form the basis for deciding if other animals should or should not be classified as arthropods. Within a phylum, however, are a number of smaller groups called classes. Certain differences among members of Arthropoda can be used to group this large phylum into different classes.

In this investigation, you will

- (a) examine two preserved arthropods—a grasshopper and a crayfish.
- (b) look for similarities in these two animals that may be phylum traits.
- (c) look for differences in these two animals that may be class traits. Grasshoppers belong to the class Insecta whereas crayfish belong to the class Crustacea.

Materials

preserved grasshopper
preserved crayfish

Procedure

• Use the following list of specific traits as a guide for completing Table 39-1 on page 155. Examine each animal and decide if the animals do or do not show the trait being described. Complete the columns marked Insecta and Crustacea.

Part A. External Characteristics

1. Are appendages (legs) present?
2. If legs are present, how many pairs does each animal have? (The large front claws of the crayfish are to be considered as legs.)
3. If present, are the legs jointed or unjointed? (Can you see joints? Are there separate sections to each leg? If so, they are jointed.)
4. Is the body divided into two or three main sections or body regions?
5. Using Figure 39-1, examine the abdomen of each animal. Is the abdomen segmented (does it appear to be in ringlike sections) or unsegmented?
6. Are there small leglike appendages along the ventral (bottom) of the abdomen?
7. Are eyes present?
8. Are feelers (antennae) present on the animal's head?
9. If antennae are present, how many are there?

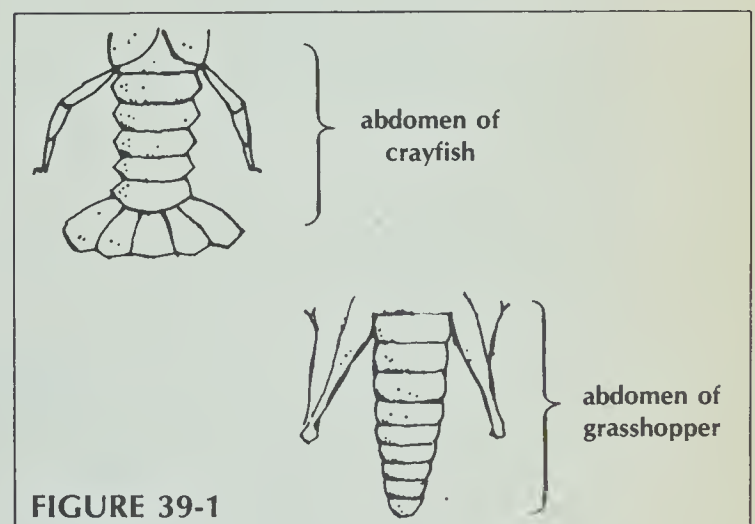


FIGURE 39-1

10. Are wings present?
11. Are small mouth parts (maxilla) present? (These mouth parts may look like small appendages.)
12. Is a fanlike tail (a telson) present?
13. Are spiracles or gills (part of the animal's respiratory system) present? Gills are feathery looking structures located at the very top of the legs. They may be observed by lifting up the side of the animal's body just where the legs join to the body. Spiracles are small holes on each side of the segments on the abdomen.

Part B. Internal Characteristics

Use Figure 39-2A and B to help answer these questions. The two diagrams show the internal parts of these two animals.

14. Is the nerve cord found along the animal's dorsal (top) side or ventral side?
15. Is the heart found along the animal's dorsal or ventral side?
16. What is the name of the excretory organ for each animal?
17. Do both animals have a similar type of digestive system? (Do both have a mouth, stomach, liver, intestine, and anus?)
18. Is the skeletal system an exoskeleton or an endoskeleton?
19. Is the circulatory system open or closed? (In an open system, the blood is not always within blood vessels or the heart. In a closed system, the blood is always within blood vessels or the heart.)
20. Is each animal both male and female (hermaphroditic) or is each animal only one sex? (The diagram will not help you. All arthropods are either male or female. The sexes are separate.)

FIGURE 39-2

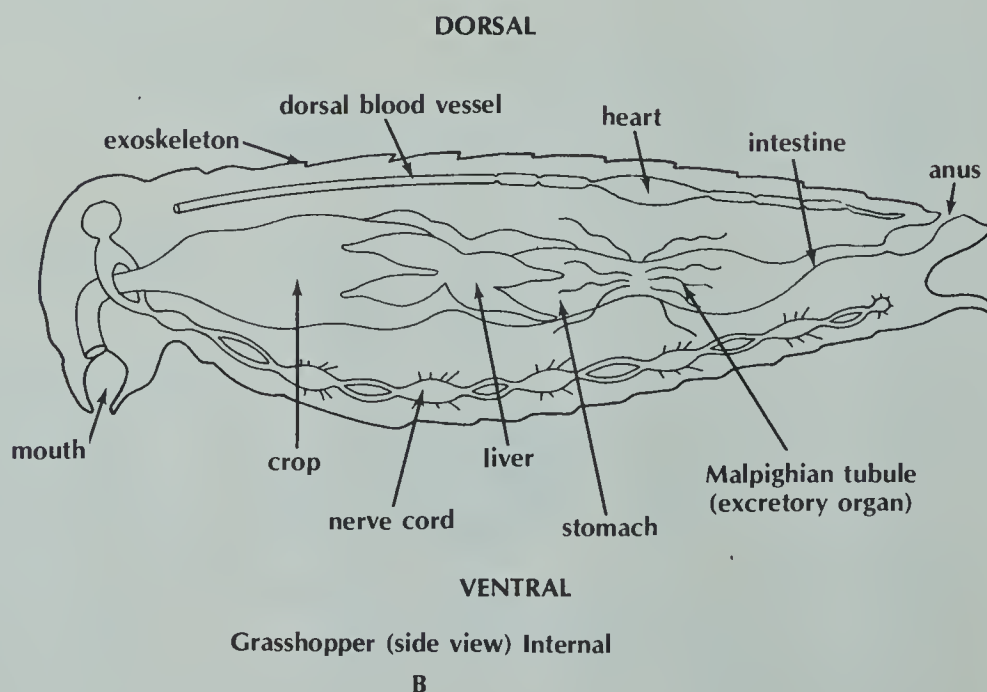
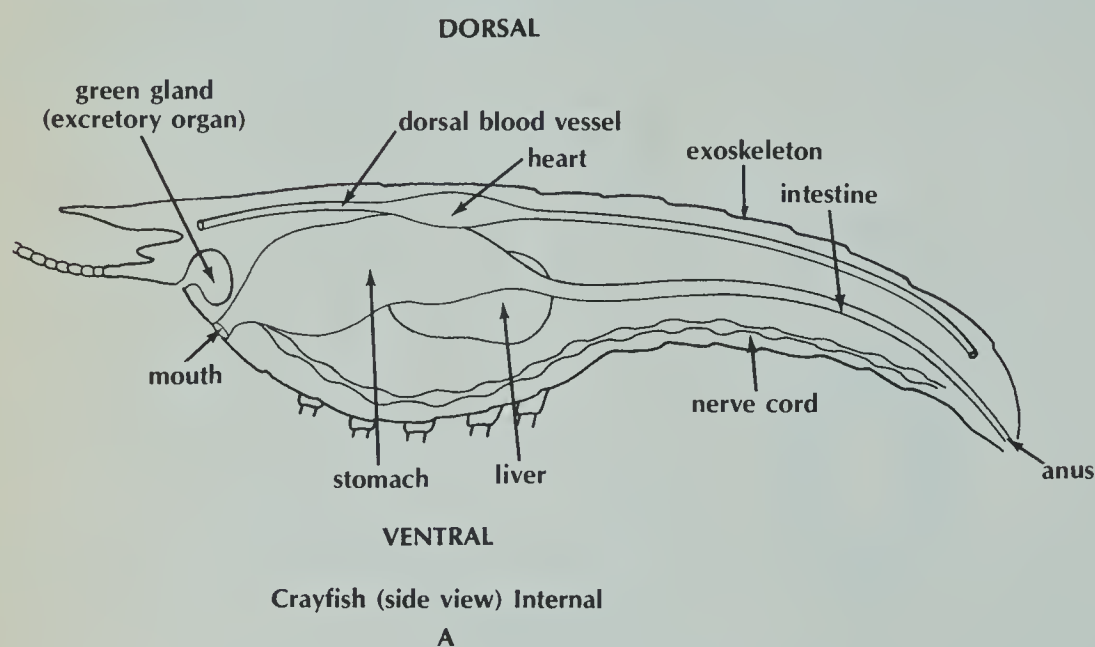


TABLE 39.1. COMPARISON OF TRAITS

CHARACTERISTIC	CLASS INSECTA (GRASSHOPPER)	CLASS CRUSTACEA (CRAYFISH)	IS TRAIT SIMILAR FOR BOTH CLASSES? (YES OR NO)
1. Legs present			
2. Number of leg pairs			
3. Legs jointed			
4. Body in regions			
5. Abdomen segmented			
6. Appendages on abdomen			
7. Eyes present			
8. Antennae present			
9. Number of antennae			
10. Wings present			
11. Mouth parts present			
12. Telson present			
13. Type of respiratory organ			
14. Location of nerve cord			
15. Location of heart			
16. Name of excretory organ			
17. Similar digestive system			
18. Exoskeleton present			
19. Type of circulatory system			
20. Sexes separate			

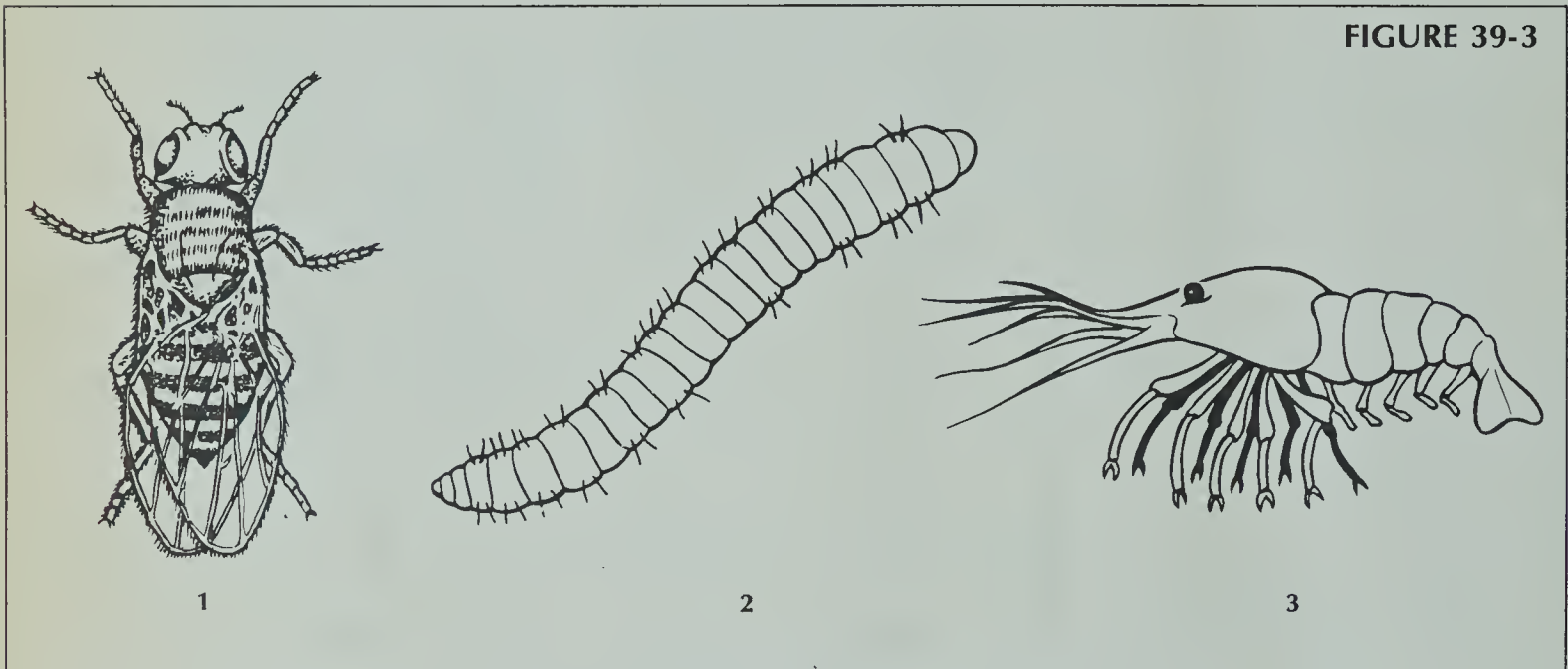
Analysis

1. A trait that is the same for both Insecta and Crustacea may be a phylum trait. List six arthropod phylum characteristics. _____

2. A trait that is different for Insecta and Crustacea may be a class trait.
 - (a) List five Insecta class traits. _____

 - (b) List five Crustacea class traits. _____

3. The word Arthropoda means jointed foot. Why is this a good phylum name for insects and crayfish?



4. (a) Which animals in Figure 39-3 should be classified as arthropods? _____
(b) List two traits that helped you decide. _____
5. (a) Which animals in Figure 39-3 should not be classified as arthropods? _____
(b) List two traits that helped you decide. _____
6. (a) Which animals in Figure 39-3 should be classified in the class Insecta? _____
(b) List two traits that helped you decide. _____
7. (a) Which animals in Figure 39-3 should be classified in the class Crustacea? _____
(b) List two traits that helped you decide. _____

STARFISH

40

Starfish are representative animals of Phylum Echinodermata. "Echin" means prickly and "derma" means skin. These animals often are referred to as spiny-skinned animals because their bodies are covered by hundreds of spines. Thus, this group of animals is appropriately named. They are marine animals.

Internal and external anatomy of a starfish, Genus *Asterias*, is interesting because of its division into five parts.

In this investigation, you will

- identify and label the major external and internal structures of *Asterias*.
- properly dissect a preserved starfish.
- list characteristics which describe members of Phylum Echinodermata.

Materials

preserved starfish
scissors
dissecting pan
hand lens

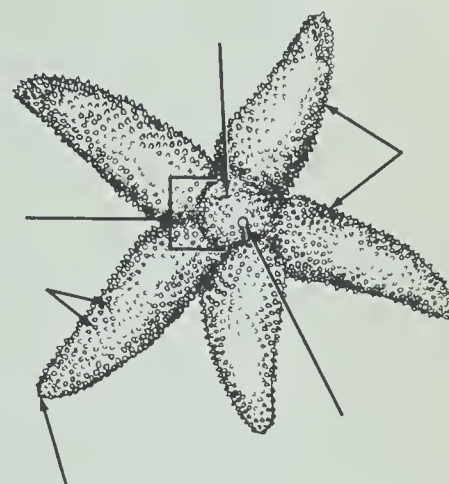
Procedure

Part A. External Anatomy

- Identify the external structures of your starfish by finding the descriptions of these parts in Table 40-1. Note that certain parts can only be seen on the dorsal (top) side of the starfish while other parts can only be seen on the ventral (bottom) side.

- Label the structures you have identified in Figure 40-1.

FIGURE 40-1

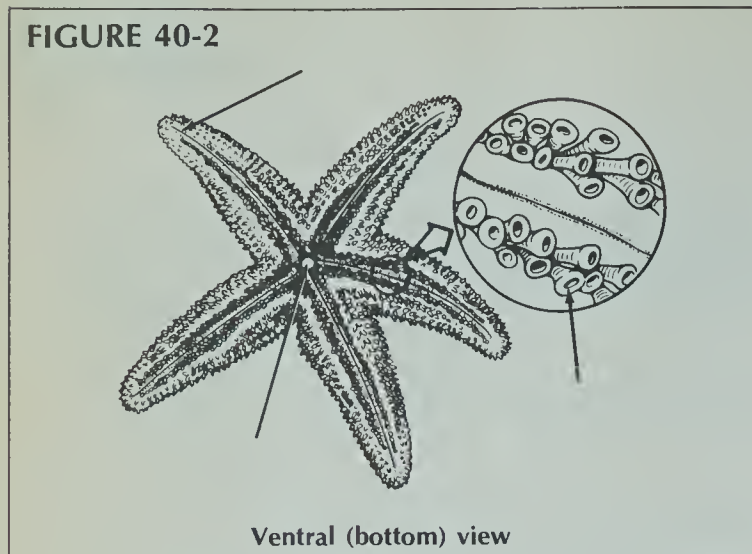


Dorsal (top) view

TABLE 40-1. EXTERNAL STRUCTURE OF STARFISH

DORSAL (TOP) VIEW	VENTRAL (BOTTOM) VIEW
<p>Central disc—center of animal, part to which "arms" are attached</p> <p>Rays—large "arms," usually numbering five</p> <p>Madreporic plate—small yellow or red structure on central disc</p> <p>Spines—hard, blunt projections covering entire surface, part of skeleton (not labeled)</p> <p>Eye spot—structure at the tip end of each arm, difficult to see in preserved specimens</p> <p>Anus—opening in center of central disk, difficult to observe</p>	<p>Mouth—opening in very center of central disc, surrounded by small spines</p> <p>Ambulacral groove—long groove running along center of each ray</p> <p>Tube feet—soft, small, dimpled structures projecting out from and lining each side of ambulacral groove, used for movement</p>

- Label the structures you have identified in Figure 40-2.



1. How many rays are present on your starfish?

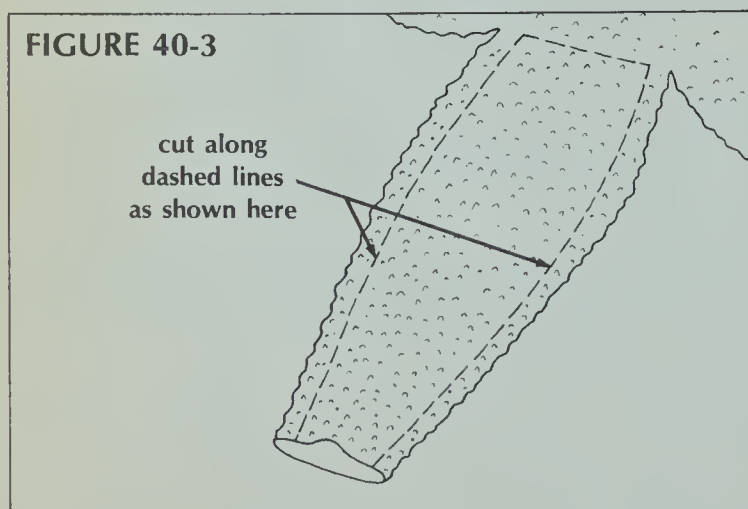
2. Describe the surface texture of the starfish (soft or hard, smooth or rough). _____
3. Explain why members of this phylum are called spiny-skinned animals. _____

4. Are the tube feet soft or hard? _____

Part B. Internal Anatomy

Digestive Organ (Pyloric cecum)

- Place your starfish dorsal side up in a pan.
 - Snip off the tip of any ray of the starfish.
- CAUTION:** *Always be careful with scissors.* With scissors, remove the skeleton from the top of the ray using Figure 40-3 as a guide. **DO NOT** cut into the central disc or into the soft tissue below the skeleton.



The large gland filling each entire ray is the pyloric cecum. This gland is part of the digestive system.

5. How many pyloric ceca does a starfish have?

Reproductive Organ (Gonad)

Starfish have separate sexes. During spawning, the gonads are large. At other times, they are small. Gonads can be distinguished by color. Testes are gray; ovaries are orange. **NOTE:** Preserved starfish parts may lose their true colors.

- Remove the entire pyloric cecum from the dissected ray of your starfish.
- Locate a ridge running along the bottom center of the ray. This ridge resembles a zipper.

Away from the tip end and along each side of this ridge are the gonads. They are two pale, lumpy organs. Each ray is identical to what you see here.

6. How many gonad pairs are in a starfish? _____

Digestive System

- Carefully cut away the top surface of the central disk. Do not remove the madreporic plate at this time. Cut around it.

A large saclike part, the stomach, should now be visible. The stomach takes up almost all of the central disk area. Small tubes may be seen extending into each arm. These tubes connect the stomach to the pyloric ceca.

7. How many stomachs are present in a starfish?

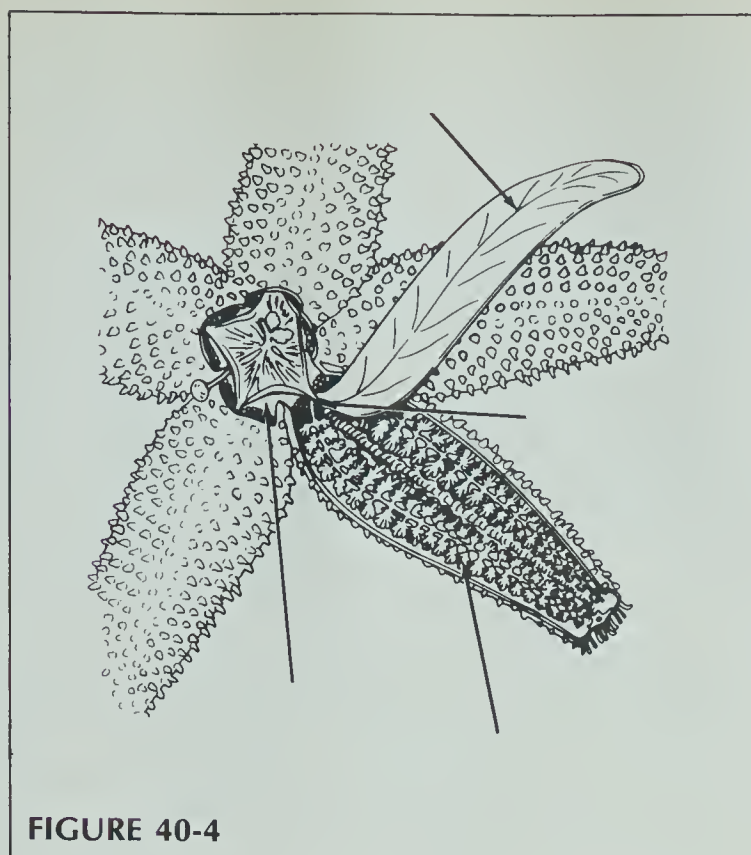
8. (a) On which surface is the mouth located?

- (b) Where is the mouth in relation to the stomach? _____

9. (a) On which surface is the anus? _____

- (b) Where is the anus in relation to the stomach? _____

- Label the following parts on Figure 40-4: *pyloric cecum* (raised and moved to one side in the diagram), *gonads*, *stomach*, *tube to pyloric cecum*.



Water Vascular System

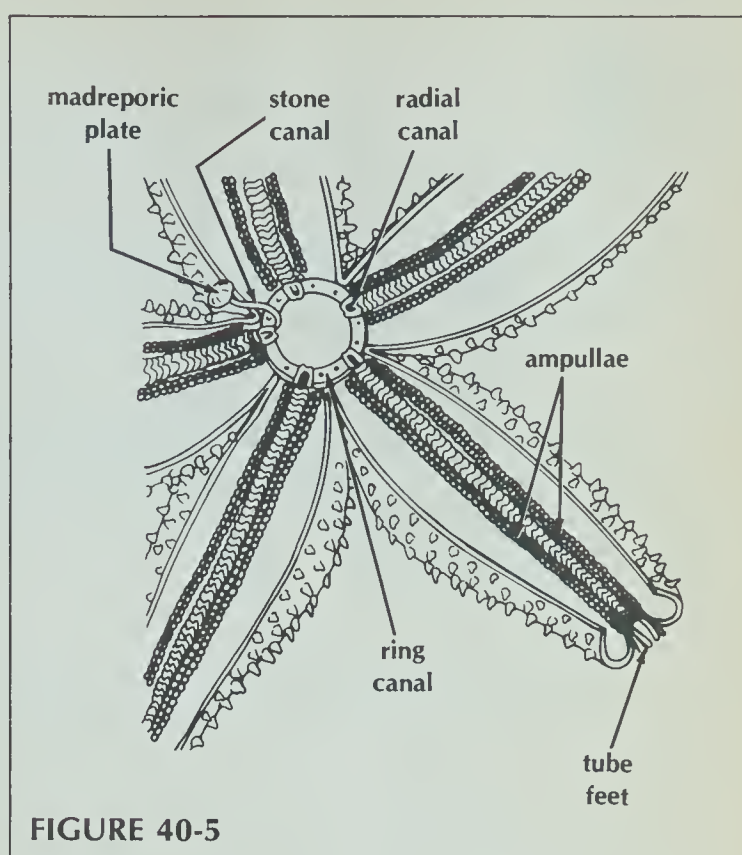
- Remove the skeleton from the top of the other four rays.

- Remove all of the pyloric ceca, stomach, and gonads. Do not remove the madreporic plate or anything connected to it.

The remaining structures in your starfish are its water vascular system. The water vascular system consists of a series of hollow tubes. Sea water enters through a starfish's madreporic plate and moves by way of canals to all body parts.

- Examine the water vascular system of your starfish.

- With a hand lens, examine the inside area along one ray for ampullae (Figure 40-5). These parts lie along the edge of the zipperlike ridge which extends the entire length of each ray of the starfish. Ampullae are bulblike and pink in color. Each ampulla is connected to a tube foot which extends through the skeletal plates onto the animal's underside. Pressure changes due to the movement of fluids inside these structures enable starfish to contract and relax muscles in each ampulla and tube foot. The tube feet act as tiny suction cups that grip objects. With the tube feet, a starfish can move and hold prey.



Inside the ambulacral groove is a long hollow tube which runs the full length of each arm. These tubes are called radial canals. They are not visible in your preserved specimen. Radial canals are connected to all ampullae and tube feet.

Each radial canal is connected to all other radial canals by a circular tube which surrounds a starfish's mouth. This canal is called a ring canal. It is now easily observed.

10. (a) What is the human vascular system?

(b) What is contained in the human vascular system? _____

11. (a) What is a starfish's vascular system?

(b) What is contained in a starfish's vascular system? _____

12. How many radial canals does a starfish have?

13. How many circular canals does a starfish have? _____

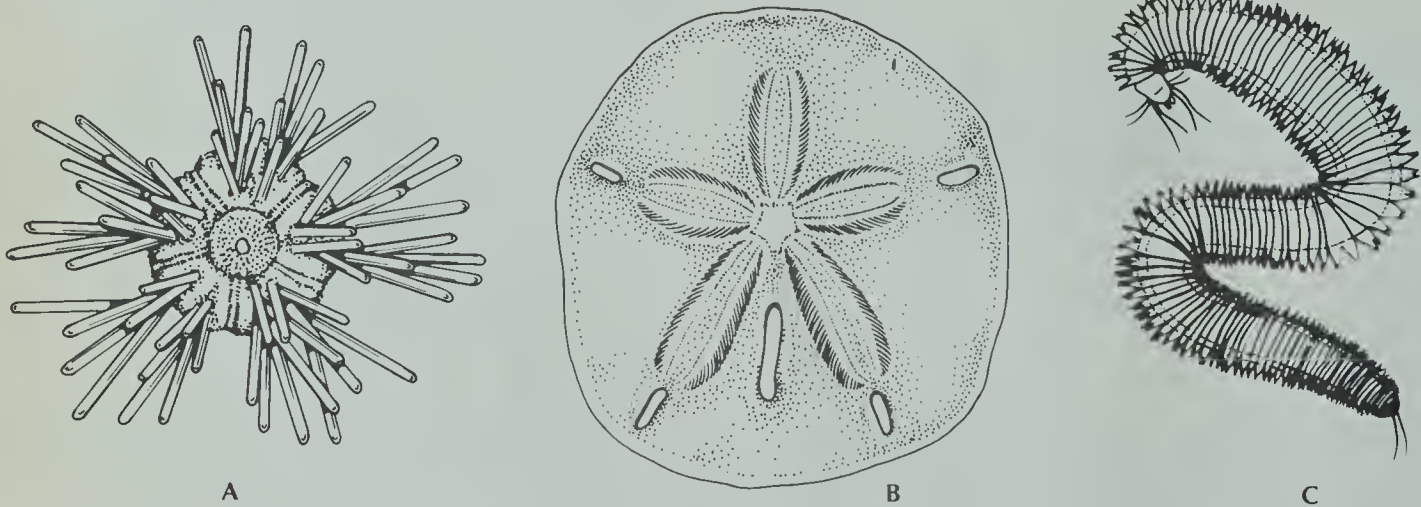
14. About how many tube feet and ampullae does a starfish have? _____

Analysis

1. (a) What evidence do you have that a starfish is organized in parts of five? _____
 (b) Has any other phylum studied so far shown this pattern? _____
2. (a) What is the meaning of the phylum term "echinodermata"? _____
 (b) Why is the starfish a good example of this term? _____
3. Complete the following chart.

STRUCTURE	SYSTEM TO WHICH IT BELONGS	FUNCTION
pyloric cecum		
spines		
mouth		
tube feet		
ring canal		
gonads		
anus		

FIGURE 40-6



4. The animals in Figure 40-6 were found in the ocean and brought back for study.
 - (a) Which do you think are echinoderms? Give reasons for your answers. _____

 - (b) Which are not echinoderms? Give reasons for your answers. _____

HOW COMMON ARE BACTERIA AND HOW QUICKLY DO THEY REPRODUCE?

41

If provided with proper conditions for maximum growth, a single bacterium can reproduce rapidly. In 24 to 48 hours so many bacteria could be produced that they form a visible mass or colony.

In this investigation, you will grow bacteria on nutrient agar, a special growth medium. To grow bacteria successfully, care must be taken to prevent contamination of the agar. Therefore, the agar and any equipment used must be sterile. Also, you must be careful not to contaminate the agar while performing the investigation. Procedures for preventing contamination are called sterile techniques.

In this investigation, you will

- learn and use sterile techniques.
- expose nutrient agar to three objects to determine if bacteria are present on the objects.
- observe bacterial colonies on your agar plate.
- evaluate your sterile techniques.
- determine places where bacteria are likely to be found.

Materials

sterile petri dish
tube of sterilized nutrient agar
hot plate
beaker (Pyrex)
sterile cotton swab(s)

glass marking pencil (wax)
test tube holder
Bunsen burner
tape

Procedure

- Examine a tube of sterilized nutrient agar. DO NOT remove the cotton or plastic plug. Note that at room temperature the agar is solid.
- Prepare a hot water bath.
- Put the tube of nutrient agar into the hot water bath. Keep the tube in the bath until all the agar has melted.
- Remove the tube of melted agar from the bath by using a test tube holder. **CAUTION:** *Test tube is very hot. Handle only with test tube holder.*
- Remove the cotton or plastic plug from the test tube mouth. Quickly pass the mouth of the test tube through a flame (Bunsen burner) two or three times (Figure 41-1). **CAUTION:** *Always be careful around open flames. Be sure hair and clothes are secured away from the flame.*

FIGURE 41-1

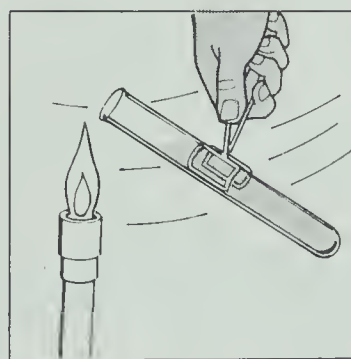
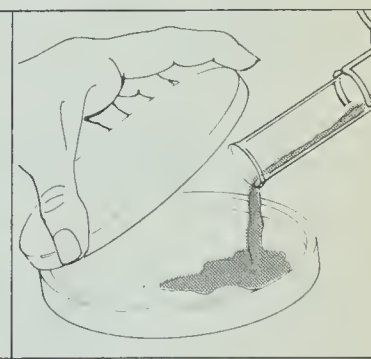


FIGURE 41-2



- Raise the cover of a sterile petri dish just enough to allow room for the mouth of the test tube. Carefully pour the liquid agar into the petri dish. Be careful not to touch the test tube against the dish. (Figure 41-2).
- Position the petri dish cover so that steam may escape from one edge (Figure 41-3). Replace the cover over the bottom after one minute. DO NOT move your petri dish until the agar has solidified (about five to ten minutes).

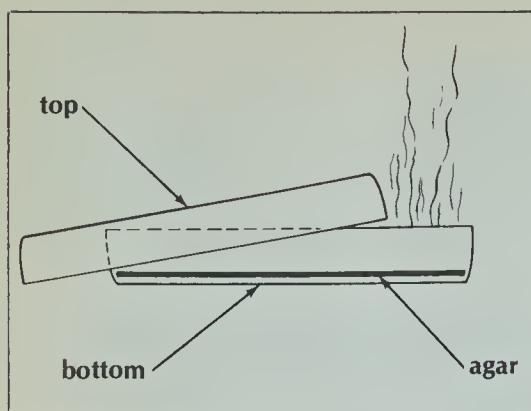


FIGURE 41-3

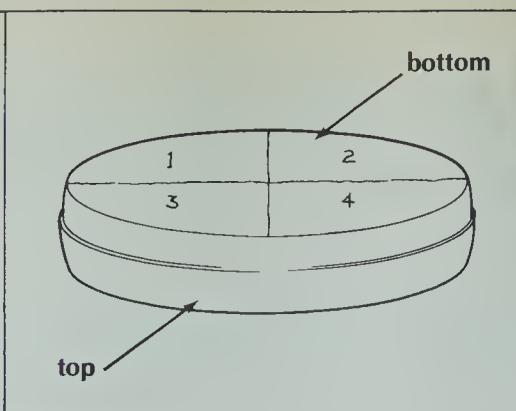


FIGURE 41-4

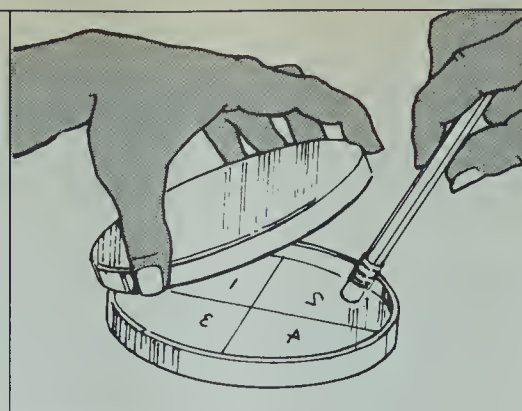


FIGURE 41-5

- After the agar has solidified, divide your petri dish into quarters by marking the outside bottom surface of the dish with a marking pencil. Number the sections one to four (Figure 41-4).

- Select three objects or surfaces to test for the presence of bacteria. Each object or surface selected is to be touched to its own numbered quarter of agar. Objects such as coins, pencils, food, or fingers can be touched lightly but directly to the agar surface and then removed. Figure 41-5 shows how a pencil eraser can be touched to quarter two. Samples of surfaces such as desk tops, classroom floors, plant soil or aquarium water may be tested by rubbing a sterile cotton swab onto these surfaces and then lightly rubbing the swab across one of the agar quarters. Use a new swab for each surface tested.

- Note that the cover of the dish should be only partly raised while samples are being applied to the agar. See Figure 41-5.

- Leave one section unexposed. This section will be your control.

- Record in Table 41-1 the type of surface or object exposed to each section of the agar.

- Add your name and the date to the dish with a marking pencil. Tape your petri dish shut to prevent contamination.

- Place your dish upside down in an incubator at 37°C.

- After 24 or 48 hours, remove your petri dish from the incubator.

- Without removing the cover, observe the agar surface for any bacteria colonies. Bacterial colonies may be observed usually as white, cream, or yellow dots. White, fuzzy colonies are molds.

Each single bacterium cell that may have been present on the object or surface tested has been given a chance during the 24-48 hours to reproduce into millions of bacteria. Each clump or colony represents what was one original cell placed on your agar surface.

TABLE 41-1. OBSERVATIONS OF CULTURE

PETRI DISH SECTION	OBJECT OR SURFACE TESTED	NUMBER OF BACTERIA COLONIES
1		
2		
3		
4		

Analysis

On a separate piece of paper, write two paragraphs describing

- what sterile technique is, what specific steps were taken during the experiment to help ensure sterility, why sterile technique was important in this experiment, and how successful your sterile technique was.
- conditions needed to grow bacteria rapidly, speed at which bacteria reproduce when placed in favorable conditions, how it was possible to detect the presence of bacteria, and what surfaces did or did not contain bacteria.

REPRODUCTION IN FUNGI

42

All fungi reproduce asexually by forming microscopic, one-celled structures called spores. These cells, once released from the parent, will form a new organism if supplied with moisture and food. Fungi form many more spores than will ever mature into new organisms. Chances are a few spores will find suitable growth conditions and will form new organisms.

In this investigation you will:

- examine spores from three different fungi.
- compare the shape and numbers of spores formed by these three fungi.
- estimate the number of spores formed by one mushroom by using a sampling technique.

Materials

microscope	dropper
glass slide	bread mold
coverslip	tweezers
water	<i>Peziza</i> (preserved)
pencil with eraser	mushroom
scissors	hand lens or dissecting microscope

Procedure

Part A. Reproductive Structures of Bread Mold

- Use a hand lens or dissecting microscope to observe the mold growing in a dish. This mold is common bread mold.

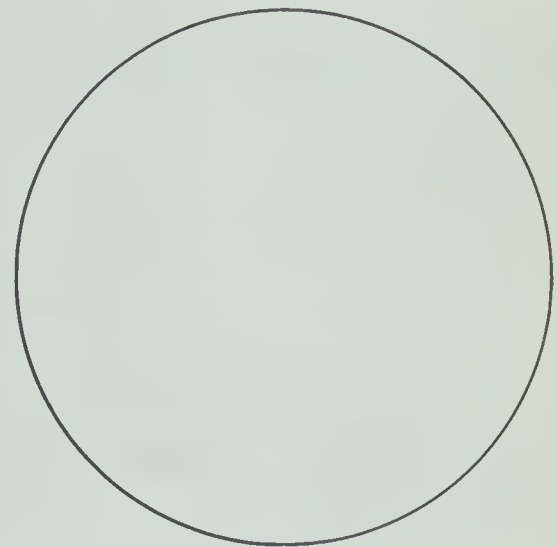
1. Describe the appearance of bread mold. _____

2. What color is the bread mold? _____

- Use tweezers to remove a small piece of the mold from the dish and prepare a wet mount.

- Observe the mold under low and high powers.

A number of structures resembling "lollipops" can be seen. Each stalk has a ball-like structure called a sporangium sitting on top of it. The sporangia are covered with many tiny black dotlike structures called spores. Some spores may have broken loose and can be seen free of the sporangia. Spores are the reproductive parts of fungi. Spores are one cell in size and can form a new fungus if they are provided with ideal growing conditions.



bread mold spores

3. Describe the shape of bread mold spores.

4. Are there few or many spores formed by one fungus? _____

- Diagram what you see in the space provided. Label the spores.

Part B. Reproductive Structures of Cup Fungus

● Observe the mold called *Peziza* or cup fungus. What you are looking at is the reproductive structure of this fungus.

5. Describe the appearance of *Peziza*. _____

6. What color is *Peziza*? _____

● Prepare a wet mount of *Peziza* by following these steps:

● *Step 1*: Use scissors to cut off a very small piece of *Peziza*. **CAUTION:** Always be careful with scissors.

● *Step 2*: Place the fungus on a clean glass slide.

● *Step 3*: Add 2 to 3 drops of water.

● *Step 4*: Place a coverslip over the water and fungus.

● *Step 5*: Using the eraser end of a pencil, gently press down on the top of the coverslip to spread out the fungus.

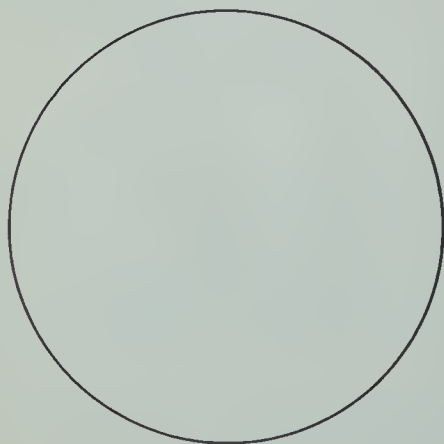
● *Step 6*: Observe the fungus under low and high powers.

● Look for areas on the slide where one or two fingerlike tubes, asci, can be clearly seen. (The entire fungus is made up of asci.) Each ascus contains spores.

7. Describe the shape of cup fungus spores. _____

8. How many spores are present within each ascus? _____

● Diagram what you see in the space provided. Label the spores.



Peziza spores

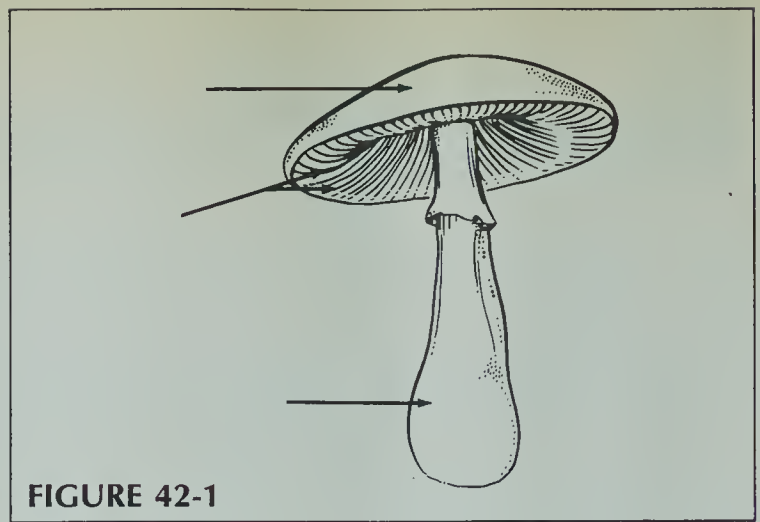


FIGURE 42-1

Part C. Reproductive Structures of a Mushroom

● Identify the three main parts of a mushroom. They are (a) stipe—stalklike part of mushroom, (b) pileus—cap on top of mushroom, and (c) gills—thin, dark brown strips on underside of pileus.

● Label these three parts on Figure 42-1. These three parts of the fungus are its reproductive structures.

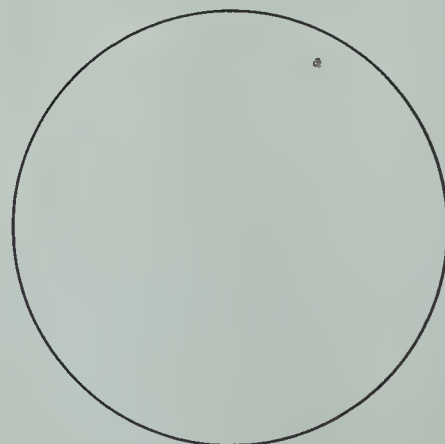
9. What color is a mushroom? _____

● To observe the reproductive structures of a mushroom, follow the six steps listed in Part B for making a wet mount. This time, however, remove a gill from the mushroom and place it on a glass slide. The tiny dark brown dotlike structures seen through the microscope are spores.

10. Describe the shape of mushroom spores. _____

11. Are there few or many spores found on one gill? _____

● Diagram what you see in the space provided. Label the spores. Save your wet mount for Part D.



mushroom spores

Part D. Calculating the Number of Spores Formed by One Mushroom

How many spores are produced by one mushroom? It would be a difficult and unpleasant task to count each spore. There is a way, however, of determining the approximate number of spores formed. A sampling technique and some simple mathematics may be used to help determine the approximate number of spores.

- Using the gill wet mount from Part C, count the number of spores that can be observed on one gill under high power. The area you are looking at is called a high power field of view or high power field. Use the row marked Trial 1 in Table 42-1 to record your result.

- Move your slide so that you are looking at a new high power field of the same gill. Count and record

TABLE 42-1. SPORES COUNTED UNDER HIGH POWER

TRIAL	NUMBER OF SPORES
1	
2	
Total	
Average	

spore numbers again using the row in Table 42-1 marked Trial 2.

- Average the number of spores counted in Trials 1 and 2 and record this number in Table 42-1.

TABLE 42-2. CALCULATING THE NUMBER OF SPORES ON ONE MUSHROOM

	SAMPLE DATA AND CALCULATIONS	YOUR DATA AND CALCULATIONS
Average number of spores counted under high power	(A) 10	(A') (From Table 42 -1)
Area of one high power field (Assume ALL scopes are the same)	(B) .08 mm ²	(B') .08 mm ²
Area of one gill measuring 10 × 2 mm (Assume all gills are the same size)	(C) 20.0 mm ²	(C') 20.0 mm ²
Number of high power fields on each gill	(D) $\frac{C}{B}$ or $\frac{20.0 \text{ mm}^2}{.08 \text{ mm}^2} = 250$	(D') $\frac{C'}{B'}$ or $\frac{20.0 \text{ mm}^2}{.08 \text{ mm}^2} = 250$
Number of spores on one side of gill	(E) $A \times D$ or $10 \times 250 = 2500$	(E') $A' \times D'$ or _____ $\times 250 =$ _____
Number of spores on both sides of gill	(F) $E \times 2$ or $2500 \times 2 = 5000$	(F') $E' \times 2$ or _____ $\times 2 =$ _____
Average number of gills on one mushroom	(G) 160	(G') 160
Number of spores on one mushroom	(H) $F \times G$ or $5000 \times 160 = 800\,000$	(H') $F' \times G'$ or _____ $\times 160 =$ _____

● Compute the total number of spores in one mushroom, following the steps shown in Table 42-2. The first column is done for you as an

example. You complete the second column. (Note: Assumptions have been made with certain values or numbers to help simplify the calculations.)

Analysis

1. (a) What colors were the fungi used in this investigation? _____
(b) Do fungi have chlorophyll? _____
(c) What do your answers to (a) and (b) tell you about how fungi obtain food? _____

2. Write a general description of the spores seen in this investigation. Include shape, number of cells, and size. _____

3. Use a word or phrase that best describes the number of spores formed by
(a) bread mold _____
(b) *Peziza* _____
(c) mushroom _____
4. Fungi cannot always be seen growing in nature. Yet, the potential for producing new fungi is tremendous.
(a) What evidence do you have from Part D of this investigation that one fungus has a high reproductive capability? _____

(b) Why are there so few fungi if their reproductive capability is so high? _____

5. There are two places in Part D where assumptions were made.
(a) How could the assumption that all gills measure $10\text{ mm} \times 2\text{ mm}$ be corrected? _____

(b) How could the assumption that all mushrooms have 160 gills be corrected? _____

GAS EXCHANGE IN MICROORGANISMS

43

Chemical indicators are often used to detect the presence or absence of certain substances. These indicators can be used to determine if unicellular microorganisms such as yeast and bacteria exchange gases with the environment.

In this investigation, you will

- (a) observe living yeast and bacteria under the microscope.
- (b) use bromthymol blue to determine if these microorganisms release carbon dioxide.
- (c) use methylene blue to determine if these microorganisms take up oxygen from their environment.

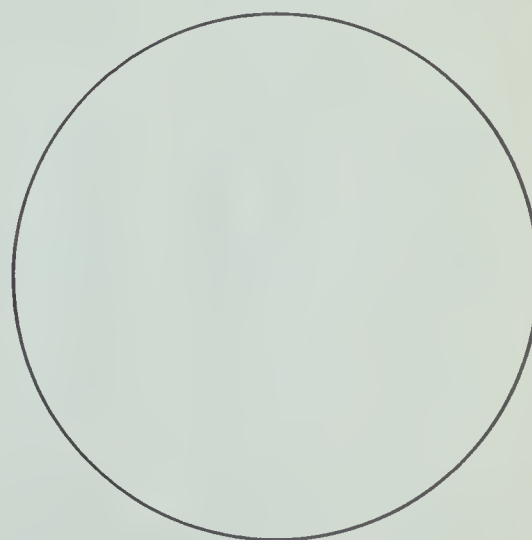
Materials

microscope
glass slides—2
coverslips—2
droppers—3
bromthymol blue solution
methylene blue solution
yeast mixture
bacteria (in bean water)
test tubes—6
glass marking pencil (wax)
rubber or cork stoppers—6
metric ruler
beaker, small
cooking oil
rubber bands
incubator (optional)

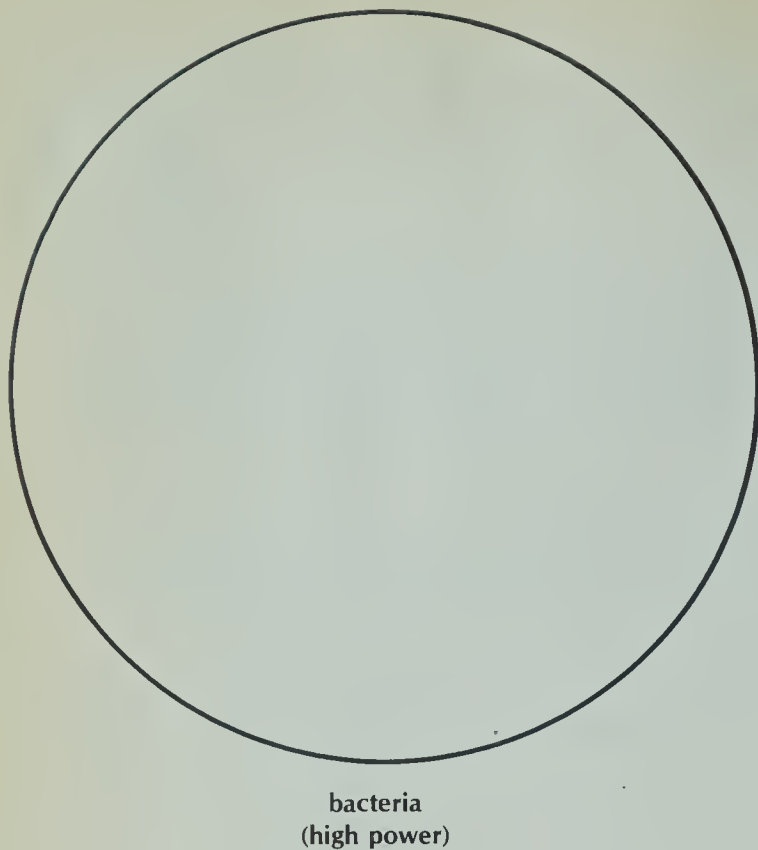
Procedure

Part A. Observing Microorganisms to be Used for Experimentation

- Place one drop of the yeast mixture on a clean glass slide. Add a coverslip and observe under low and high powers. Diagram several yeast cells in the space provided.
- Place one drop of bean water on a clean glass slide. The bean water contains bacteria. Add a coverslip and observe under high power. (NOTE: It may be difficult to see the individual bacteria clearly even under high power, but you should see them shaking and shimmering.)
- Diagram the bacteria in the space provided on the following page.



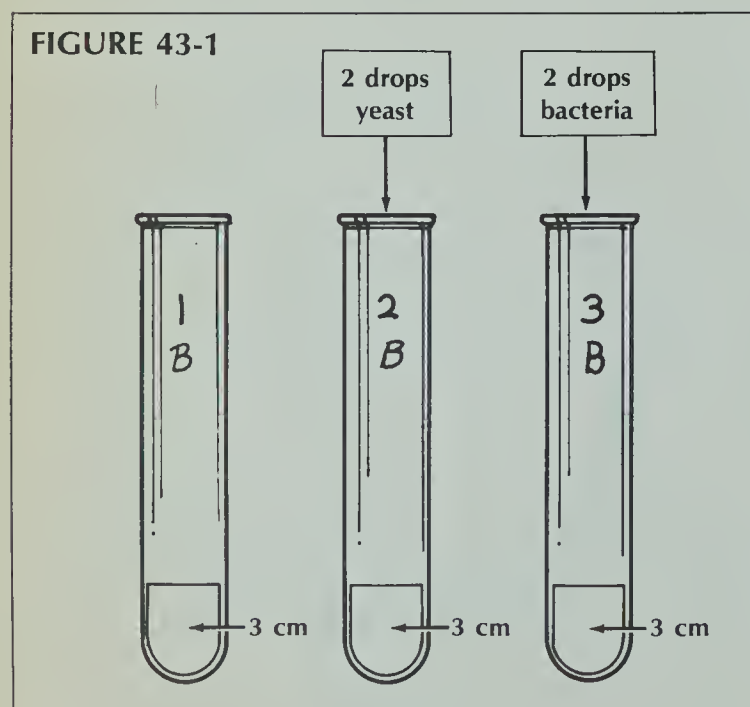
yeast
(high power)



Part B. Carbon Dioxide Release by Microorganisms

Bromthymol blue can detect if carbon dioxide gas is present. If carbon dioxide is present, bromthymol blue will change color from its normal blue to a greenish blue, green, or yellow.

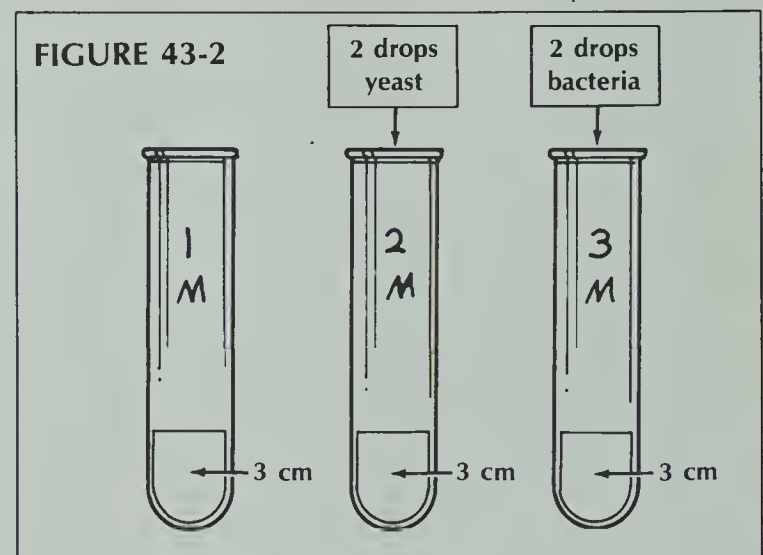
- Number three test tubes one to three. Mark the letter "B" below each number.
- Fill each tube to a height of 3 cm with bromthymol blue.
- Add the solutions shown in Figure 43-1 to the tubes.



- Stopper each tube tightly.
- Put a rubber band around the three tubes and put them aside.

Part C. Oxygen Uptake by Microorganisms

- Methylene blue can detect if oxygen gas has been used. If oxygen is used, methylene blue will change color from its normal deep blue to a light blue or colorless condition.
- Number three test tubes one to three. Mark the letter "M" below each number.
- Fill each test tube to a height of 3 cm with methylene blue.
- Add the solutions shown in Figure 43-2 to the tubes.



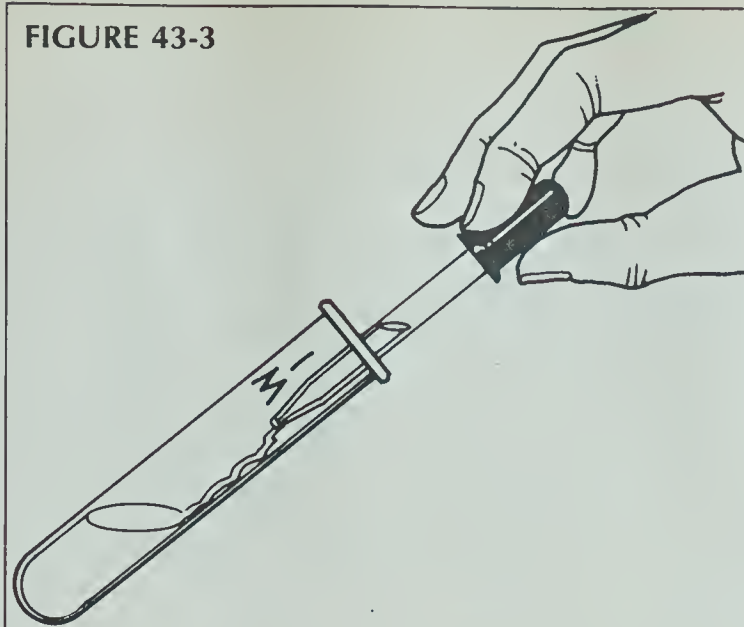
- Tip each tube. Slowly run a dropper full of oil down the side of each tube. Use Figure 43-3 as a guide. The methylene blue is now "sealed" from the oxygen in the upper part of the tube.

- Stopper each tube tightly.
- Put a rubber band around the three tubes. Place these tubes and the three tubes from Part B into a small beaker. Label the beaker with your name. Use Figure 43-4 as a guide.
- Incubate the tubes at 37°C overnight (or set in a warm place within the room). In 24 hours, observe the tubes and complete Part D.

Part D. Observing and Recording Results

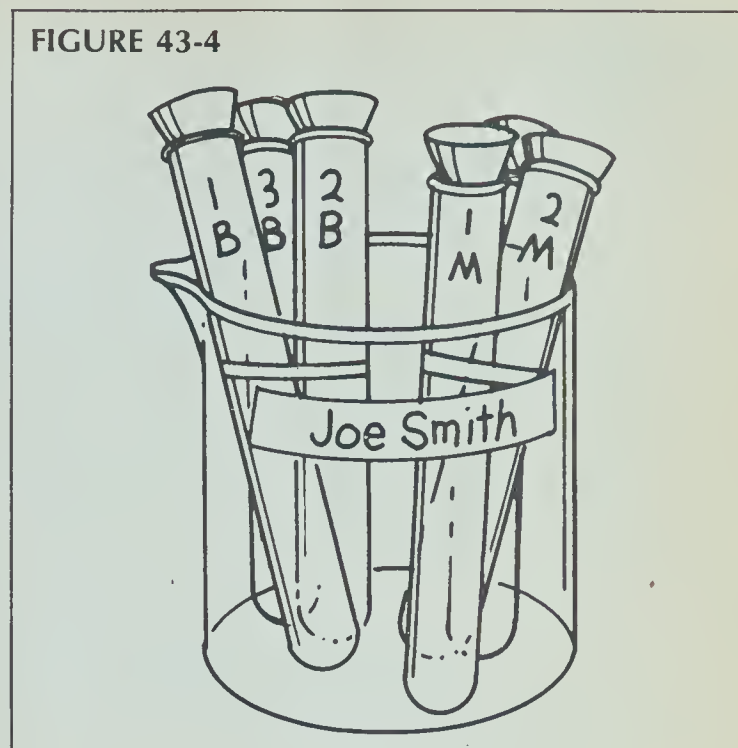
- Examine the three tubes marked "B." Compare the colors of tubes two and three to tube one (the control).

FIGURE 43-3



- Note and record the colors of each tube in Table 43-1. Use these colors only: blue, blue-green, green, yellow.
- Complete the remaining columns for these three tubes. Reread Part B for the meaning of color changes.
- Examine the three tubes marked "M." Compare the colors of tubes two and three to tube one (the control).

FIGURE 43-4



- Note and record the colors of each tube in Table 43-1. Use these colors only: deep blue, light blue, colorless. Disregard any color that appears in the oil layer.
- Complete the remaining columns for these three tubes. Reread Part C for the meaning of color changes.

TABLE 43-1. RESULTS OF EXPERIMENTS

TUBE	COLOR AFTER 24 HOURS	ORGANISM IN TUBE	CARBON DIOXIDE RELEASED?	OXYGEN USED?
1B			—	—
2B				—
3B				—
1M			—	—
2M			—	
3M			—	

Analysis

- (a) To which kingdom do yeasts belong? _____
- (b) To which kingdom do bacteria belong? _____

2. Write a description of yeast. Include shape, size, color, number of cells seen. _____

3. Write a description of bacteria. Include shape, size, color, number of cells seen. _____

4. (a) Explain how one can detect if microorganisms are releasing carbon dioxide gas. _____

(b) What process may organisms be undergoing during carbon dioxide release? _____

5. (a) Explain how one can detect if microorganisms are using oxygen gas. _____

(b) What process may organisms be undergoing during oxygen gas uptake? _____

6. (a) Why was oil used to cover the methylene blue in Part C? _____

(b) How might your results have differed in Part C if no oil cover were used? _____

7. A student first boiled the yeast and bacteria before adding them to the tubes of methylene blue and bromthymol blue. Predict the student's results and explain why the results occurred. _____

8. Yogurt, cottage cheese, and buttermilk all are made from bacterial cultures. These cultures provide some of the special taste and texture of these foods. Explain what you might have seen in the test tubes had you used these foods to test for evidence of gas exchange. _____

FUNGAL NUTRITION

44

Molds are organisms which belong to the Kingdom Fungi. Molds therefore have characteristics different from organisms in the protist and moneran kingdoms.

How do fungi differ from protists and monerans? First, they are not unicellular. Fungi are usually multicellular (have many cells) and often can be seen without a microscope. Fungi cells also have nuclei. Fungi contain no chlorophyll, and so are not able to make their own food. Organisms in this kingdom are either saprophytes or parasites. Saprophytic fungi get their food by feeding off once-living material. Parasitic fungi get their food by feeding off living material.

In this investigation, you will

- (a) observe bread mold using a hand lens or binocular microscope.
- (b) note some of the characteristics or traits of bread mold.
- (c) determine if bread mold can grow on a variety of different surfaces.
- (d) determine if bread mold can use a variety of chemicals as food sources.

Materials

hand lens (or binocular microscope)
dish containing living bread mold
small jars with covers—8
water

labels or marking pencil
cardboard from a box
corn starch

potato flakes
raisins
cotton swabs—8

Procedure

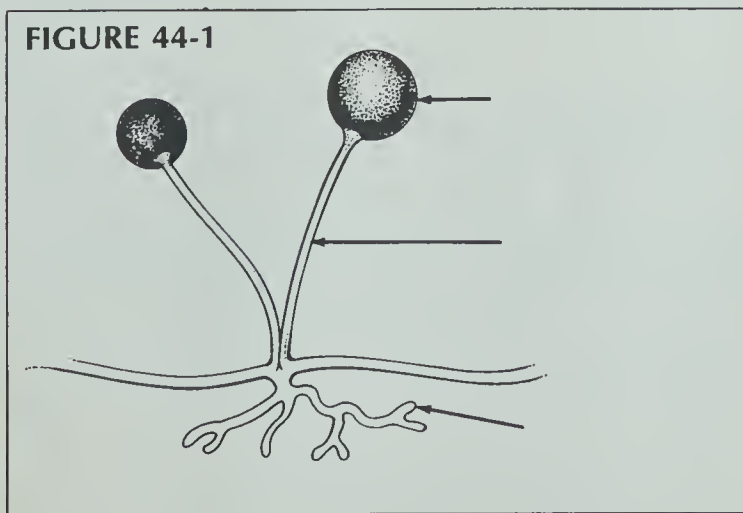
Part A. Observing Bread Mold

- Use a hand lens to observe bread mold growing in a petri dish.
- Note the following parts:
 - (a) Tiny round structures (usually black) called sporangia are on top of a long clear stalk. These structures form reproductive spores.
 - (b) Stalklike parts (usually clear) called sporangiophores hold up the sporangia.

- (c) A mass of threadlike structures (usually clear) spread along the surface of the mold's food supply. These structures are called stolons and they enable the mold to secure its food.

- Label the following parts on Figure 44-1: *sporangia*, *sporangiophore*, *rhizoid*.

FIGURE 44-1



Part B. Testing Different Chemicals and Surfaces as Possible Sources of Food

Four different surfaces and chemicals will be tested as possible food sources for bread mold. If a food source is usable by bread mold, the mold will grow quickly and can be easily observed in a few days. If a food source is not usable by bread mold, the mold will not grow and cover the surface of the food source.

Prepare 8 small jars as follows:

- Label the jars with your name and the numbers one to eight.

- Place the following items into the jars:
Jar 1: cover the bottom with dehydrated (dry) potato flakes.
Jar 2: cover the bottom with dehydrated potato flakes and add enough water to make a paste.
Jar 3: cover the bottom with cornstarch.
Jar 4: cover the bottom with cornstarch and add enough water to make a paste.
Jar 5: cover the bottom with dry raisins.
Jar 6: cover the bottom with dry raisins and add enough water to soak them thoroughly.
Jar 7: stand a small piece of cardboard upright in the jar.
Jar 8: stand a small piece of cardboard upright in the jar and add a small amount of water to the bottom of the jar.

● Rub a damp cotton swab over the surface of the bread mold studied in Part A. Rub the swab over the surface of the contents of jars one to eight. Use a different swab for each jar.

● Cover each jar and let it sit for several days at room temperature.

TABLE 44-1. RESULTS OF MOLD GROWTH

JAR	CONTENTS	MOLD GROWTH?
1	dry potato flakes	
2	wet potato flakes	
3	dry cornstarch	
4	wet cornstarch	
5	dry raisins	
6	wet raisins	
7	dry cardboard	
8	wet cardboard	

- After several days, examine each jar for the presence or absence of bread mold growth.
- Record your observations in Table 44-1.

Analysis

- How do fungi differ from protists and monerans? _____
- In which jars did bread mold grow? _____
 - Does bread mold seem to grow only on bread? _____
 - Can bread mold use a variety of foods for its nourishment? _____
 - Were rhizoids present? _____
 - What function do rhizoids have in bread mold? _____
 - Describe the appearance and function of two other bread mold structures. _____
- Define the words
 - saprophytic. _____
 - parasitic. _____
- Using your definitions from Question 3, decide if bread mold growing on each of the following is a parasite or a saprophyte.
 - bread _____
 - wet potato flakes _____
 - wet cardboard _____

CONTROL OF DISEASE-CAUSING BACTERIA

45

You probably know that the water you drink or the pool water in which you swim contains chlorine. Most large cities add chlorine to drinking water for the same reason that it is added to swimming pools—chlorine kills bacteria. Water is a perfect environment for the growth of bacteria. Thus, the addition of chlorine to water keeps it free of possible disease-causing bacteria.

In this investigation, you will

- (a) learn how to determine if a water sample contains chlorine.
- (b) calculate the amount of chlorine present in a water sample.
- (c) compare the amount of chlorine present in five different water samples.

Materials

chilled tap water sample
swimming pool water sample
distilled water sample
water sample "A"
water sample "B"
graduated cylinder
droppers—3
flask - 250 mL (or beaker)
hydrochloric acid (in plastic bottle)
potassium iodide
starch solution
sodium thiosulfate solution
tweezers

Procedure

Step 1. Measure 200 mL of tap water into a graduated cylinder. Pour the water into a flask.

Step 2. Use the tweezers to add a small crystal of potassium iodide (size of a pea) to your water sample.

Step 3. Add 20 drops of hydrochloric acid to your water sample. **CAUTION:** *Do not spill acid on skin or clothes. Rinse with water and call your teacher immediately if spillage occurs.*

Step 4. Add 20 drops of starch solution to your water sample. **NOTE:** A blue color indicates that chlorine is present in your sample. No blue color indicates no chlorine present in your sample.

Step 5. If no chlorine is present, record your results in Table 45-1. If chlorine is present, go on to step 6.

Step 6. Determine the amount of chlorine in your water sample. Add sodium thiosulfate, one drop at a time, to your flask. Swirl the sample after each drop. Count and record the number of drops of sodium thiosulfate needed to turn the water sample colorless again.

Step 7. Complete Table 45-1. The amount of chlorine is recorded in "parts per million" or PPM. (An amount of 3 PPM means there are 3 parts of chlorine in one million parts of water.) Multiply the number of drops of sodium thiosulfate needed to turn the water colorless by 0.2 to determine PPM of chlorine in your sample.

Step 8. Repeat steps 1 to 7 with the remaining four samples provided (distilled water, pool water, sample A, and sample B). Wash and dry flask thoroughly between tests.

TABLE 45-1. CHLORINE TEST RESULTS

WATER SAMPLE	CHLORINE PRESENT?	NUMBER OF DROPS OF SODIUM THIOSULFATE USED	PPM OF CHLORINE PRESENT
Tap Water			
Distilled water			
Swimming pool			
"A"			
"B"			

Analysis

- Why is chlorine added to drinking or swimming pool water? _____
- What is meant by 10 PPM of chlorine? _____

- Of the samples tested (except distilled water),
 - which had the highest PPM of chlorine? _____
 - which had the lowest PPM of chlorine? _____
 - which of these two samples probably contains the least number of bacteria? _____

- Should your tap water sample contain chlorine? _____ Did it? _____
 - Explain how it may be possible that your tap water sample read "no chlorine present" when most city water has chlorine added to it. (HINT: Chlorine is added to tap water as a gas at a water processing plant.) _____

- Distilled water should contain no chlorine. What is meant by distilled water? _____

- Occasionally, after a flood or the breaking of a major water pipe, people are advised to boil their drinking water.
 - What does boiling do to bacteria that may have gotten into the water? _____

 - Drinking water in some countries can cause serious illness to visitors. What may be in the water that causes the illness? _____

 - Why is this problem not often found in Canada today? _____

USING ANTIBIOTICS TO STOP BACTERIAL GROWTH

46

Antibiotics such as penicillin or streptomycin are major chemicals used in combating disease. These drugs stop the spread of infections by killing bacteria. In the laboratory, the effectiveness of an antibiotic is tested by adding the antibiotic to a bacterial culture. Clear zones on the culture near the antibiotic indicate lack of bacterial growth. These zones are called zones of inhibition.

In this investigation, you will:

- (a) apply bacteria to a sterile agar petri dish.
- (b) add antibiotic disks to the agar surface using sterile techniques.
- (c) incubate the dish and look for zones of inhibition to determine which antibiotic is most effective in stopping bacterial growth.

Materials

tube of sterilized nutrient agar
sterile petri dish
hot plate
beaker (Pyrex)
water
Bunsen burner (or alcohol lamp)
sterile cotton swab
tweezers
antibiotic disks—3 different types
glass marking pencil (wax)
metric ruler
broth culture of *Escherichia coli*
sterile paper disk
incubator
small jar with water

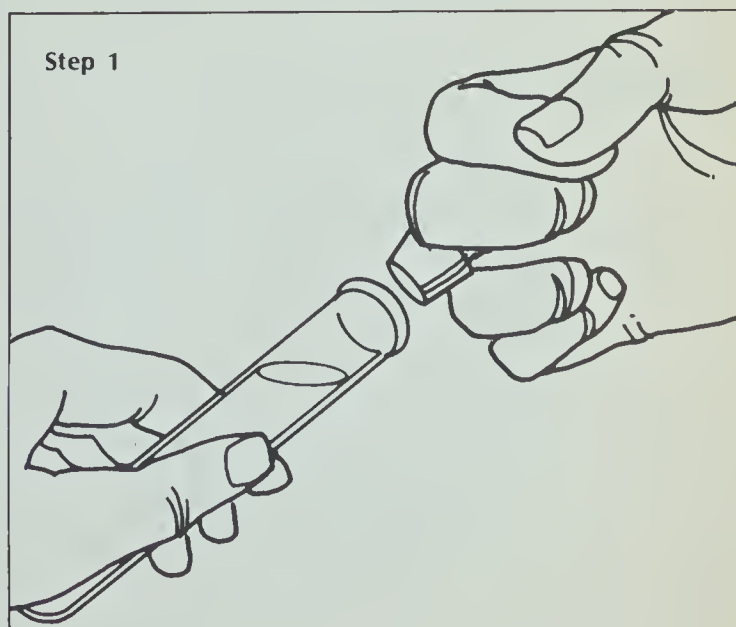
Procedure

● Prepare a sterile nutrient agar petri dish using the technique described in Investigation 40. Remember to allow the agar to solidify before going on with the experiment.

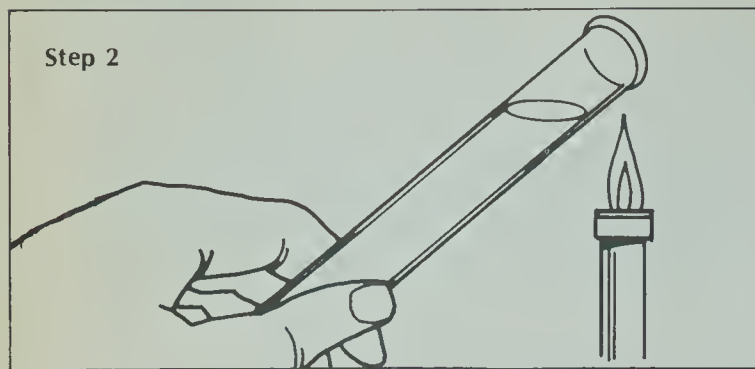
● Examine a broth culture (a tube containing the bacteria in a liquid). The liquid contains food for the bacteria. Do not spill the broth culture. To spread the bacteria from the broth culture onto the agar surface of your petri dish, follow these steps.

● READ ALL STEPS BEFORE YOU START.

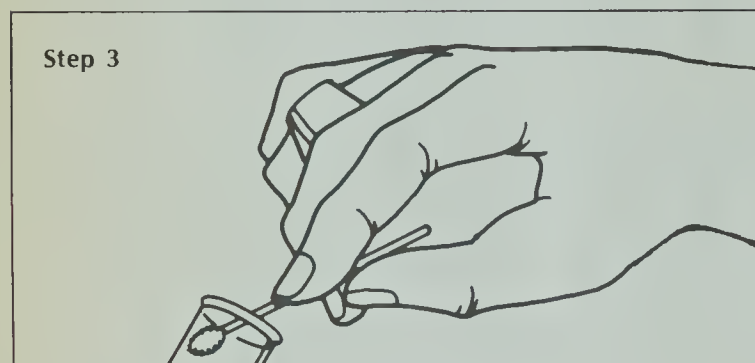
● *Step 1.* Remove cap or plug from broth tube. DO NOT place cap or plug on table, but continue to hold between fingers.



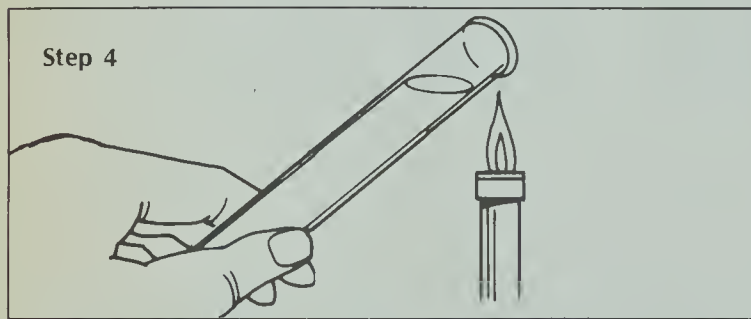
- *Step 2.* Heat mouth of tube in a bunsen burner. **CAUTION:** Always be careful around open flames. Secure all loose hair and clothing before proceeding.



- *Step 3.* Moisten a sterile cotton swab by dipping it into the broth culture.

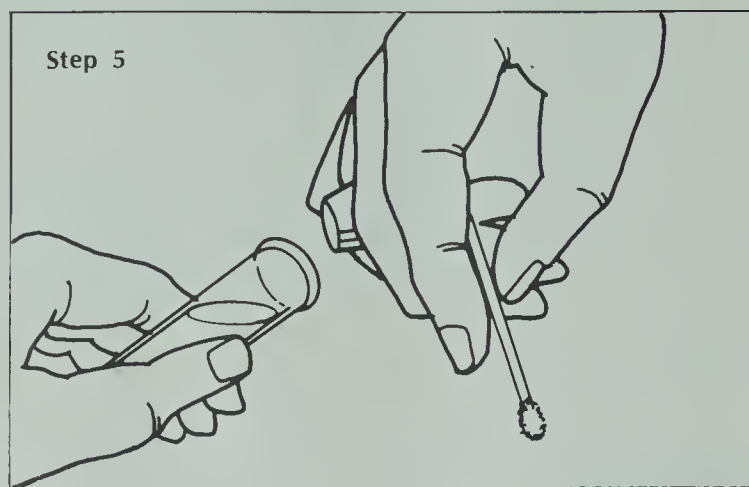


- *Step 4.* While still holding the swab (and cap or plug) in one hand, reheat the mouth of the broth test tube.



- *Step 5.* Replace the cap or plug on the test tube.

- Raise your petri dish cover slightly. Starting at the top, rub the cotton swab across the entire agar surface. Use a back and forth motion to guarantee that the entire surface has been covered with the broth culture. Now turn the petri dish a quarter of a turn and rerub the swab across the agar surface. Use Figure 46-1 as a guide.



- Replace the cover of the petri dish. To dispose of the swab, burn the tip of the swab in the flame of the bunsen burner, then place the swab in the jar of water.

Your agar has now been inoculated (exposed) with the bacteria in the broth culture. The bacteria will reproduce and form colonies on the agar.

- With a marking pencil, divide the dish into four quarters by marking on the outside of the dish bottom. Number the quarters one to four.

- Obtain three antibiotic disks from your teacher. Use tweezers to place each disk in the center of a separate quarter of your agar plate. Press each disk lightly onto the agar surface.

FIGURE 46-1

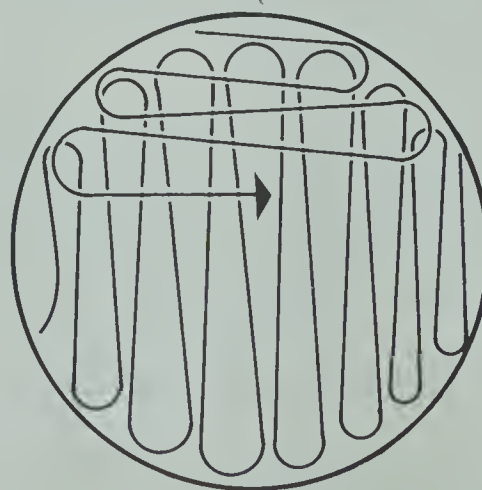
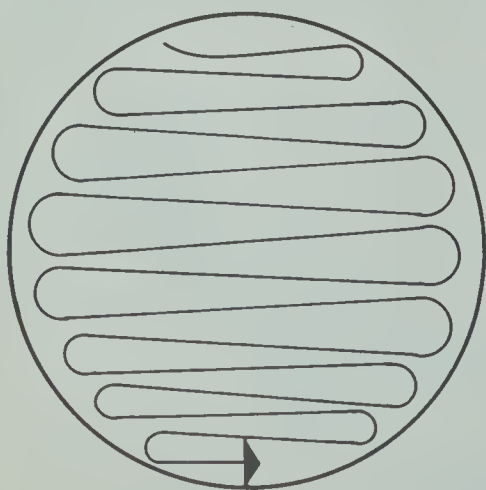
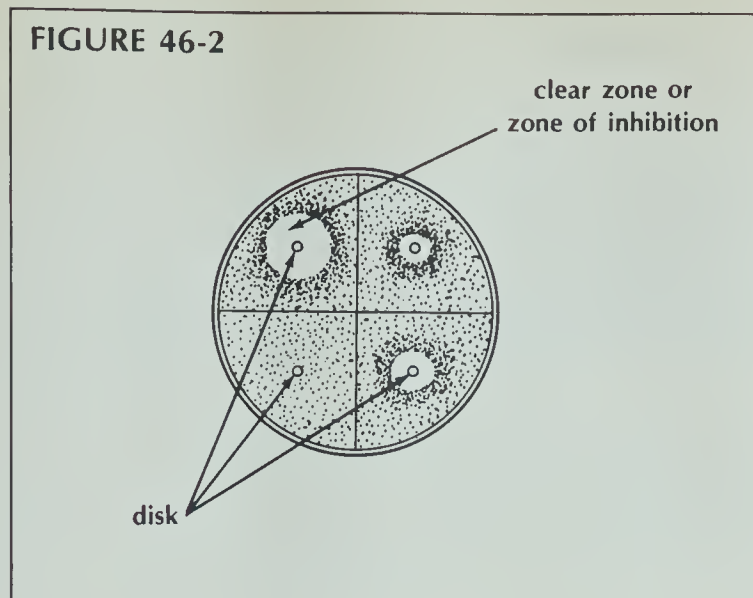


FIGURE 46-2



- Add a plain sterile paper disk to the remaining quarter. This disk will be your control.
- Sterilize your tweezers after applying the fourth disk by passing them through the flame of a bunsen burner.

● Record in Table 46-1 the name of the antibiotic used in each quarter of the petri dish.

● Invert your petri dish. Label it with your name and the date. Incubate the petri dish for 24 to 48 hours at 37°C.

If any of the antibiotics are effective against bacterial growth, there will be a clear area (zone of inhibition) around the disk. The antibiotic in the disk has prevented bacterial growth if a zone of inhibition is present.

● Examine your dish after incubation. DO NOT open the petri dish. Look for zones of inhibition surrounding the paper disks (Figure 46-2). They may be more easily seen if the dish is held toward the light.

● Measure the diameter of each clear zone in millimetres. Record your results in Table 46-1. If no clear zone appears, record the diameter as 0.

TABLE 46-1. OBSERVATION OF EFFECTS OF ANTIBIOTICS

PETRI DISH QUARTER	ANTIBIOTIC USED	DIAMETER OF ZONE OF INHIBITION IN MM
1		
2		
3		
4		

Analysis

1. How were you able to judge if an antibiotic stopped or inhibited bacterial growth? _____

2. Which antibiotic

- (a) has the largest zone of inhibition? _____
- (b) has the smallest zone of inhibition? _____
- (c) is the most effective in stopping growth of the species of bacteria used? _____
- (d) is the least effective in stopping the species of bacteria used? _____

3. (a) What was the scientific name of the bacterium used in this experiment? _____

- (b) Would your results be the same if you had used a different species? _____

Explain. _____

- (c) Would your results have been the same if you had used different antibiotics? _____

Explain. _____

4. What experimental proof do you have that the paper disk itself cannot prevent bacterial growth?
HINT: What was the purpose of using a control, and how effective was the control in preventing

bacterial growth? _____

5. In this experiment, what purpose was served by the

- (a) broth culture? _____

- (b) agar? _____

- (c) cotton swab? _____

- (d) incubation of the dish for 24 hours? _____

6. A man arrives at a doctor's office with a bacterial infection (boil) on his hand. The doctor has ten different antibiotics she could give to the man. How can she find out which antibiotic will work best

against the infection? Outline a procedure that the doctor can use. _____

FLOWER ANATOMY

47

Flowers are more than ornamental parts of a plant. They are the reproductive structures of angiosperms, the flowering plants. Flowers are structures for sexual reproduction. Thus, angiosperms are widespread.

In this investigation, you will

- observe macroscopically and identify the reproductive structures of a plant.
- observe microscopically certain parts of flowers.
- label diagrams of the structures associated with plant reproduction.
- list the function of flower parts.
- list whether each structure is a male or female reproductive part.

Materials

tobacco flowers
razor blade (single-edge)
microscope
water
microscope slides—2

coverslips—2
hand lens (or binocular microscope)
dropper
sunflower (optional)

Procedure

Part A. Macroscopic Examination

Flowers have many different sizes, shapes, and numbers of parts. You will study a tobacco flower because it has all the flower parts.

The outside of a tobacco flower has two parts. Sepals are green, leaflike parts at the base of the flower. Tobacco has five sepals. These parts are joined so it is difficult to see each sepal. Sepals protect the young flower.

Petals are the brightly colored parts of a flower. Tobacco has five petals. However, they are fused making counting difficult. Petals protect the flower parts inside. Their colors may also attract insects.

NOTE: If using preserved flowers, the colors of petals and sepals may have faded.

- Properly label Figure 47-1 using words *sepals* and *petals*.
- Remove the petals of your flower by gently pulling them off.

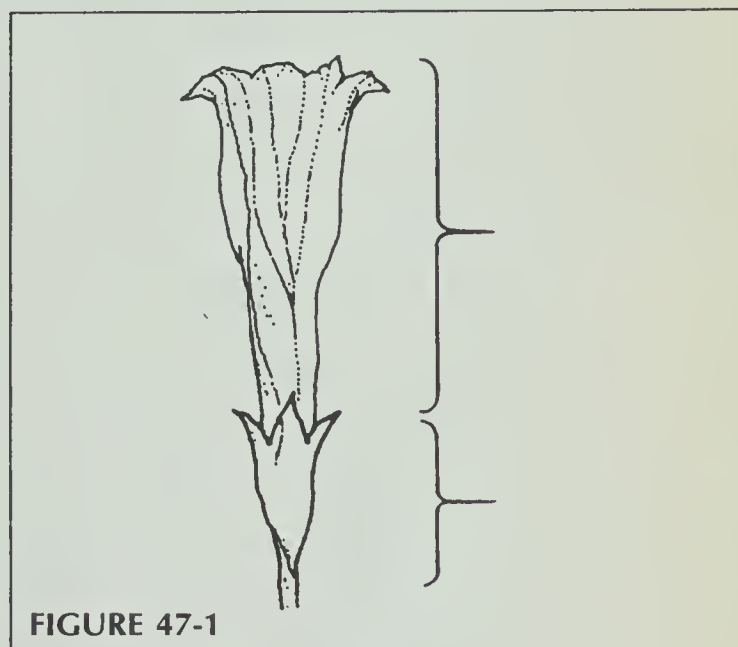


FIGURE 47-1

Two different types of parts should now be seen. The pistil is a single, slender, stalklike structure with a round base connected to the stem (see Figure 47-2). All parts which make up the pistil are associated with a flower's female reproductive system. Also, on the inside of the

petals are stamens. They are also stalklike structures. Each stamen has a two part caplike part on its end (see Figure 47-2). All parts which make up the stamen are associated with a flower's male reproductive system.

A more detailed study of a stamen reveals that it is composed of two parts. The stalk portion of a stamen is the filament. It supports the cap. The cap on the filament is the anther. The anther produces pollen grains.

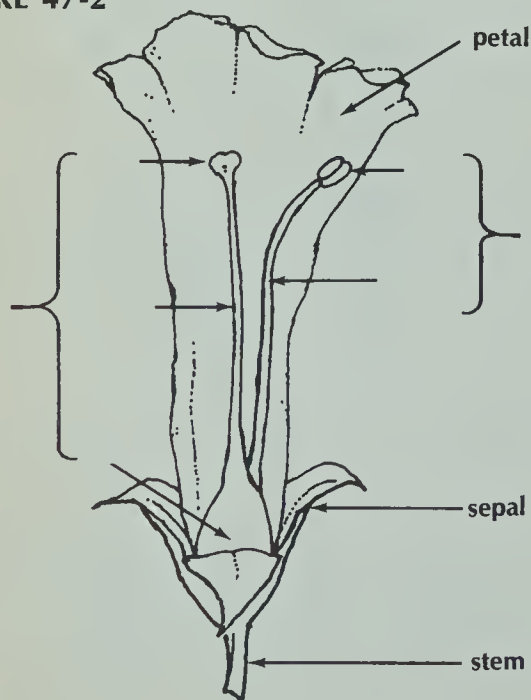
- Label *stamen*, *filament*, and *anther* in Figure 47-2.

A detailed study of the pistil reveals that it is composed of three parts. The stigma is the top portion of the pistil. It is usually sticky. The stigma is the collecting place for pollen grains. The stalk of the pistil is the style. The style supports the stigma. The base portion of the pistil is the ovary. The ovary may be partly hidden from view by the sepals. If so, remove the sepals by gently pulling them off.

- Label the *pistil*, *stigma*, *style*, and *ovary* in Figure 47-2.

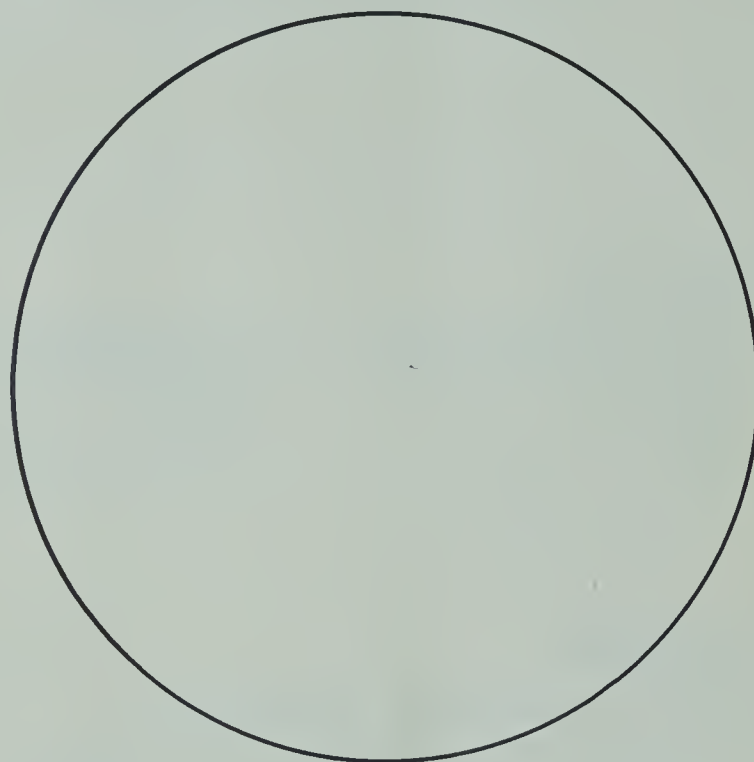
1. How many stamens are present in tobacco flowers? _____
2. How many pistils are present in tobacco flowers? _____
3. How does the number of stamens compare to the number of petals and sepals in tobacco flowers? _____

FIGURE 47-2



Part B. Microscopic Examination

- Prepare a wet mount of pollen grains. Place an anther onto a slide and add a drop of water. Cut the anther into several small pieces with the razor blade. **CAUTION: Blade is sharp. Cut away from your fingers.** Add a coverslip and gently press down to squash the anther pieces.
- Examine the anther under low and high power of your microscope. The small dotlike structures are pollen grains. Pollen grains contain the male sex cells.
- Diagram in the space provided several pollen grains as they appear under high power.



pollen grains

- Using Figure 47-3 as a guide, slice the ovary exactly in half lengthwise with a razor blade.
- Mount one half in a drop of water on a microscope slide. Make sure that the cut surface is facing up.
- Examine the ovary section with a hand lens or binocular microscope. Two structures of the ovary should be visible.

The many small, dotlike structures which fill the two ovary halves are ovules. Each ovule contains an egg cell that is not visible.

A funiculus, a tiny stalk, connects each ovule to the ovary.

- Label the *ovary*, *ovules*, and *funiculus* in Figure 47-4.

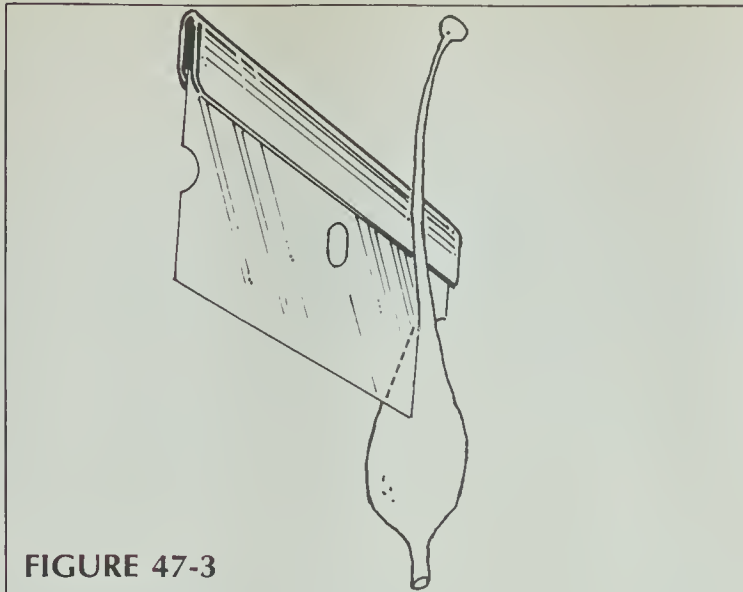


FIGURE 47-3

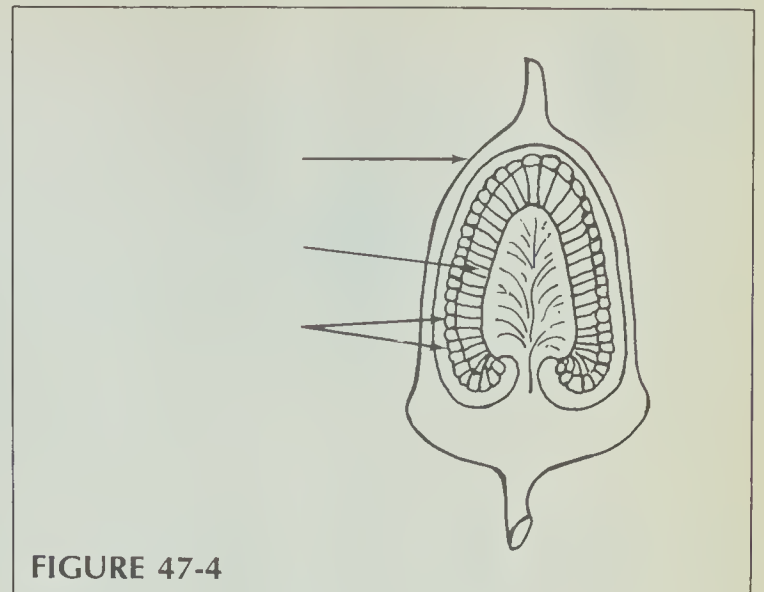


FIGURE 47-4

4. About how many pollen cells are present in each anther? (Make a reasonable guess.) _____

5. How many ovaries are present in tobacco flowers? _____

6. About how many ovules are present in tobacco flowers? (Make a reasonable guess.) _____

7. (a) Are there more pollen cells produced by one anther than ovules produced by one ovary? _____

(b) Give a possible explanation for your answer. _____

Analysis

1. Group the following parts into male and female reproductive parts. Use the space provided: pistil, stamen, filament, anther, stigma, pollen, style, ovule, ovary.

MALE REPRODUCTIVE FLOWER PARTS	FEMALE REPRODUCTIVE FLOWER PARTS

2. Give the function of the following parts.

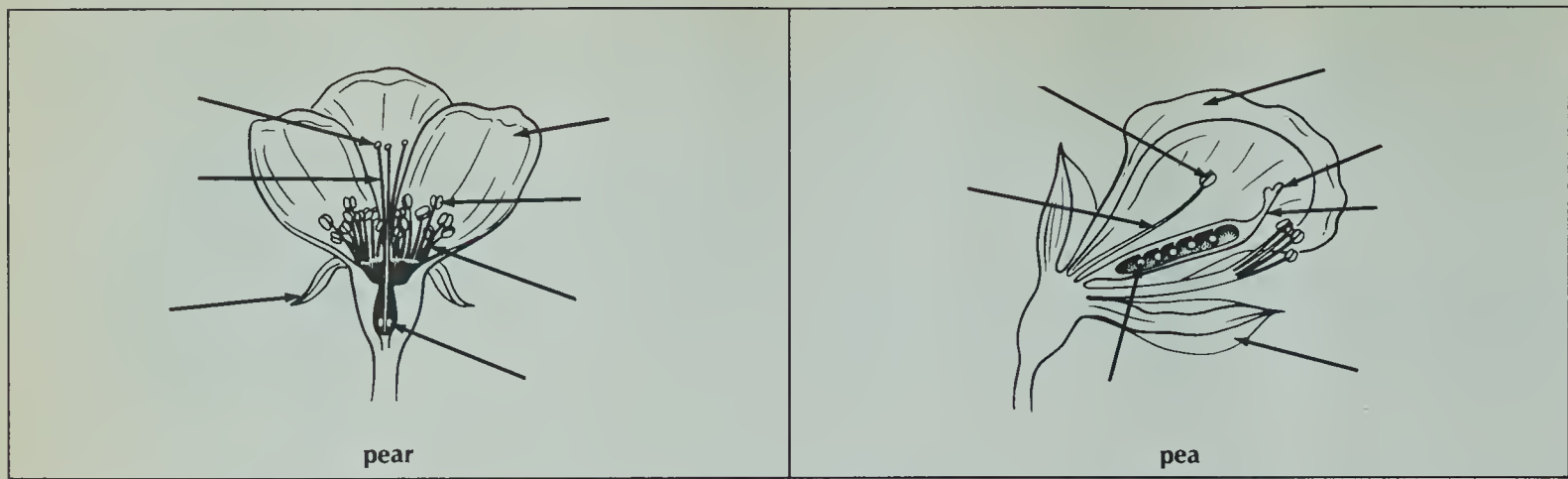
(a) sepal and petal _____

(b) anther _____

(c) stigma _____

(d) ovule _____

3. Label on the diagrams below the flower parts listed: petal, sepal, stigma, anther, style, ovary, filament.



Extending Your Investigation

Are you ready for a challenge? Using the knowledge you gained from this investigation, you will examine a sunflower. The only additional material needed is a sunflower.

- Carefully remove one of the yellow “petals,” taking with it its point of attachment to the stalk. With a razor blade, split this “petal” open lengthwise at its base.
- The “petal” is actually an entire flower and is referred to as a ray flower. Examine the flower with a hand lens. Look for evidence of the following: sepals, petals, stamens, pistil, ovary, and ovules.
- Indicate with a check mark in Table 47-1 whether or not these parts are present. Also, indicate the number of ovules present by slicing open the ovary (if present) and examining the contents with a hand lens.
- Carefully remove one of the dark center structures from the sunflower, making sure that its base portion is still attached.

● Slice this structure open lengthwise toward its base and examine with a hand lens. This structure is called a tube flower. Look for evidence of the same flower parts as in the ray flower and indicate in Table 47-1 whether or not these parts are present.

1. A sunflower is actually made up of many flowers. Are ray and tube flowers exactly alike?

2. Biologists refer to this type of flower arrangement as a composite. Why is this an appropriate name? _____

TABLE 47-1. RAY AND TUBE FLOWERS OF SUNFLOWER

	RAY FLOWER	TUBE FLOWER
Sepal		
Petal		
Stamen		
Pistil		
Ovary		
Ovule		

FRUITS AND SEEDS

48

Fruit formation is an important phase of sexual reproduction in flowering plants. Fruits protect and help distribute seeds. Fruits often are eaten by animals. The seeds enclosed within the fruit are not digested; they pass through the animals. Thus, some seeds are dispersed by animals. Because they are associated with reproduction, fruits and seeds are related to flower parts. Fruits are enlarged ovaries. Seeds are enlarged and thickened ovules.

In this investigation, you will

- (a) examine and compare traits of six different fruit types.
- (b) examine the inside parts of a string bean and okra fruit.
- (c) examine and compare outside and inside parts of a bean and corn seed.

Materials

string bean
peach
pistachio
peanut
cucumber
green pepper
okra
bean seed soaked in water
hand lens
razor blade (single-edge)
corn seed soaked in water—2

Procedure

Part A. Fruit Comparison

● Examine samples of the fruits listed in Table 48-1. Use a razor blade to cut open the fruits to examine their interiors. **CAUTION:** *Blade is sharp. Cut away from your fingers.*

● Complete Table 48-1. Base your answers on the following brief explanations.

- (a) "Nature of fruit" should be either *dry* (hard or brittle) or *fleshy* (soft and usually thick).
- (b) "Number of seeds" should be a number. For some fruits (cucumber, green pepper), an estimate rather than an actual number should be given.
- (c) "Fruit edible" should be yes or no, considering humans as the consumers.
- (d) "Seed edible" should also be yes or no, considering humans as the consumers.

- (e) "Evidence of flower parts" should be answered yes or no. A scarlike structure appears on the ends of certain fruits showing remains of reproductive parts no longer present (stigma, petals, and so on). Do not confuse this with the stalk end where the fruit was connected to the plant.

Part B. Fruit Parts

String bean pods are the fruit of a string bean plant. The string bean pod was the ovary of the bean flower. Evidence of this can be seen inside the string bean pod.

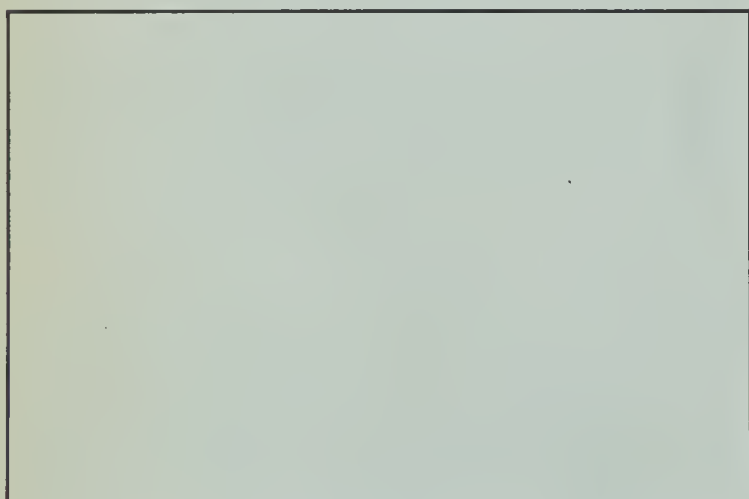
- Using a razor blade, cut the string bean pod open lengthwise. Use the "line" found along its outside as a guide.

TABLE 48-1. CHARACTERISTICS OF SOME FRUITS					
FRUIT	NATURE OF FRUIT	NUMBER OF SEEDS	FRUIT EDIBLE	SEED EDIBLE	EVIDENCE OF FLOWER PARTS
Okra					
Peach					
Pistachio					
Peanut					
Cucumber					
Green pepper					

● With the string bean pod open, identify the seeds inside. A small thin stalk can be seen connecting each seed to the fruit or pod. This stalk is the funiculus.

● Correctly add the following labels to Figure 48-1: *fruit*, *seed*, *funiculus*.

● Make a cross-sectional slice through an okra fruit. Observe and diagram what you see in the space below. Label these parts: *fruit*, *seed*, and *funiculus*.



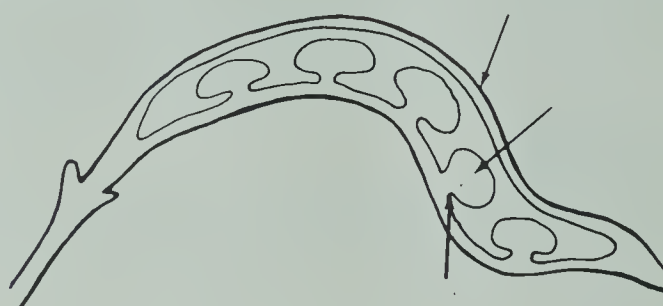
Part C. Seed Parts

● Examine a bean seed that has been soaked in water. Three structures should be visible.

An oval scar on the side of the seed is the hilum. It represents the point of attachment of the ovule by the stalklike funiculus.

The tiny dot directly below (or above) the hilum is the micropyle. It is the opening through which the pollen tube entered the ovule and the egg was fertilized.

FIGURE 48-1



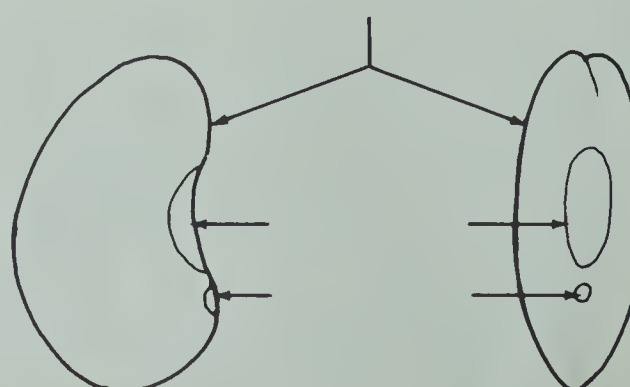
The thick, outer covering of the seed is the seed coat. It protects the seed.

● Correctly add the following labels to Figure 48-2: *hilum*, *micropyle*, *seed coat*.

● Using a razor blade, carefully remove the seed coat from your bean seed.

● Open the seed into two equal halves. Four internal structures should be visible with the aid of a hand lens.

FIGURE 48-2



Side view

Front view

The bulk of the seed is two cotyledons. They store food which is used by the developing plant during germination.

The other three parts of a seed located near the edge of one of the cotyledons form the young plant. The stemlike structure is the hypocotyl. It will form the stem of the plant. The lower tip of the hypocotyl is the radicle. It will form the roots of the new plant. The small leaflike structure connected to the hypocotyl is the epicotyl. It will form the first true leaves of the plant during its early growth.

● Correctly add the following labels to Figure 48-3: *epicotyl*, *hypocotyl*, *radicle*, *cotyledons*.

● Examine the outside of a soaked corn seed.

1. Can you see the same outer parts as easily on

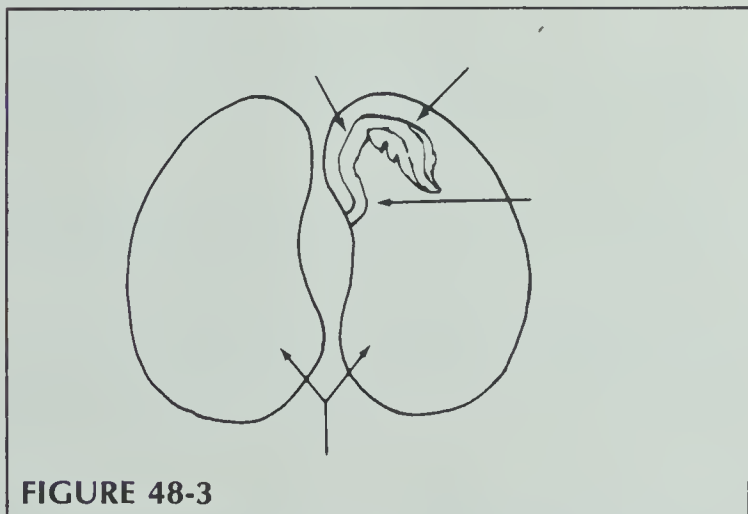
corn as you did on the beans? _____

● Using a razor blade or fingernail, carefully remove the seed coat from your corn seed.

2. Does the corn seed split open easily into two

equal halves? _____

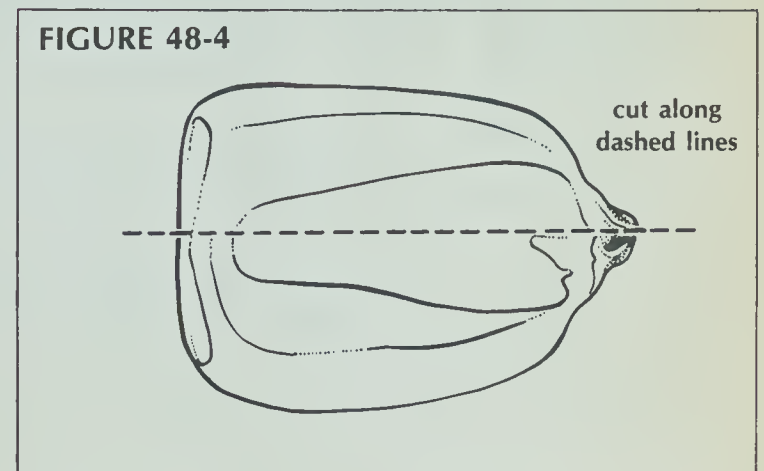
Flowering plants are grouped into two categories, monocotyledons and dicotyledons. These groups refer to the number of cotyledons present in the seeds. Mono- means one, di- means two.



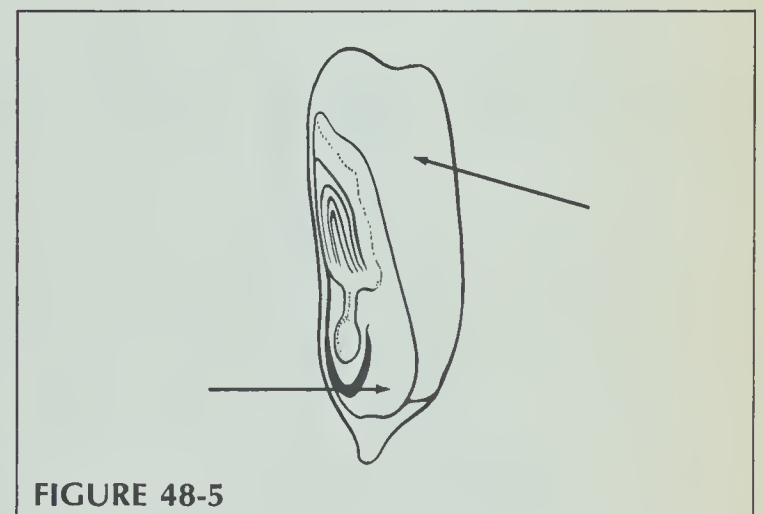
3. (a) Are beans a mono- or dicotyledon plant? _____

(b) Is corn a mono- or dicotyledon plant? _____

● Cut a second soaked corn seed in half. Use Figure 48-4 as a guide.



● Examine the cut edge. Those parts which appear white are the cotyledons, radicle, epicotyl, and hypocotyl. Together these parts form the embryo or future plant. The remaining part is a tissue called endosperm. Endosperm serves as a food source for the young embryo as it first grows. Label the *embryo* and *endosperm* in Figure 48-5.



Analysis

1. Did all fruits examined in Part A have seeds in them? _____

2. (a) Is there a relationship between the nature of a fruit (Table 48-1) and its edibility? _____

(b) Explain. _____

3. (a) Is there a relationship between number of seeds (Table 48-1) and seed edibility? _____
- (b) Explain. _____
4. (a) A string bean pod usually has five to seven seeds in it. How many ovules were present in a bean flower ovary before fertilization? _____
- (b) A tomato may have over 500 seeds in it. How many ovules were present in a tomato flower ovary before fertilization? _____
5. What structure found in string beans, green peppers, tomatoes, and cucumbers tells you that they are all fruits? _____
6. Categorize each of the following plant parts as either fruits or vegetables. (Consider vegetables as a nonscientific category assigned to any plant or plant part other than a fruit.) Give reasons to support your decisions.
- (a) strawberry _____
- (b) beet _____
- (c) squash _____
- (d) pumpkin _____
- (e) lettuce _____
- (f) carrot _____
7. Explain what each of the following parts is or does.
- (a) hilum scar _____
- (b) micropyle _____
- (c) cotyledon _____
- (d) embryo _____
- (e) endosperm _____
8. Explain what becomes of each of the following seed parts as the seed sprouts.
- (a) hypocotyl _____
- (b) epicotyl _____
- (c) radicle _____
9. Define
- (a) monocotyledon (monocot). _____
- _____
- _____
- (b) dicotyledon (dicot). _____
- _____
- _____

MOSS PLANTS AND ALTERNATION OF GENERATIONS

49

Moss plants are rather unimportant economically. However, they are important from an evolutionary viewpoint. A number of significant changes have occurred in plant evolution from mosses to flowering plants. Mosses (and most other plants) have alternation of generations during their life cycles. This term means that a gametophyte, or gamete producing plant, alternates with a sporophyte, or spore producing plant. In more complex plants, the gametophyte plant is greatly reduced in size while the sporophyte plant predominates. In mosses, both plant generations are visible without a microscope.

In this investigation, you will

- properly prepare moss plant parts for microscopic observation.
- compare your microscopic moss parts with diagrams of male gametophytes, female gametophytes, and sporophytes.
- identify gametophyte and sporophyte moss plants.
- complete a diagram showing alternation of generations in moss plants.

Materials

microscope slides—4

microscope

tweezers

dropper

razor blade (single-edge)

water

3 types of moss plants

moss antheridium, prepared slide

moss archegonium, prepared slide

Procedure

Part A. External Structure

- Observe the external features of a moss plant.
- Compare the general size of moss plants with familiar plants such as grasses, tulips, and trees.

The structures of mosses look like leaves, stems, and roots. However, they are not true leaves, stems, or roots because they lack vascular tissue (conducting tissue).

Part B. Reproductive Structures of the Gametophytes

You will be given two moss plants. Externally, they look alike. However, they are different.

- With tweezers, remove all the leaflike structures from the upper 1 cm portion of the stemlike part of each plant. Be careful not to remove the structures at the tip of the "stems" (see Figure 49-1).

FIGURE 49-1



- Place each plant onto opposite ends of a microscope slide. With a razor blade, cut the stemlike structure of each moss plant 0.5 cm from the tip end. **CAUTION: Blade is sharp. Cut away from your fingers.** Discard the "leafy" part of the plant (see Figures 49-2 and 3).

FIGURE 49-2

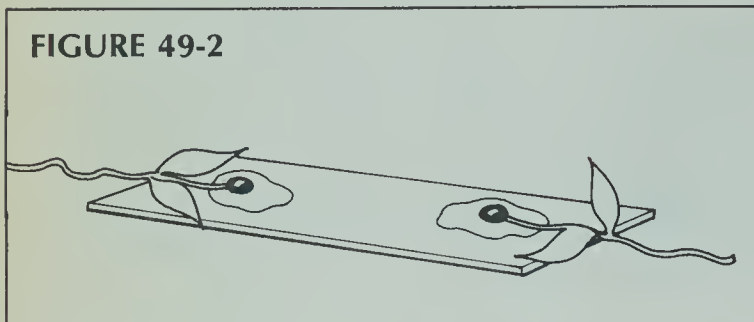
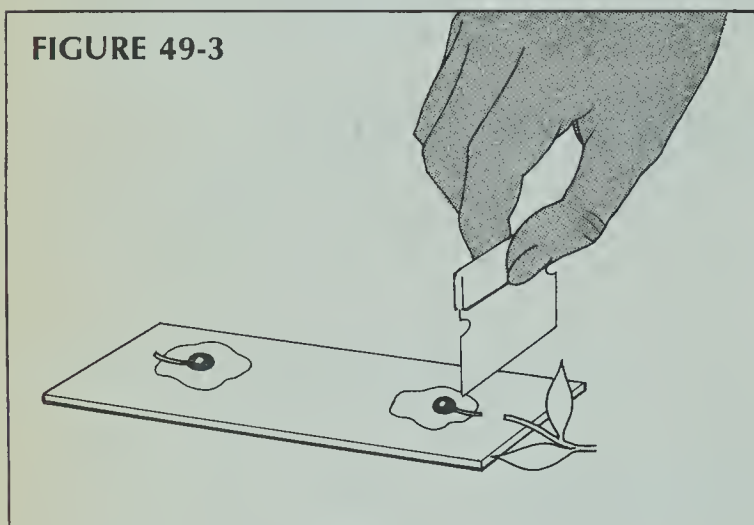


FIGURE 49-3

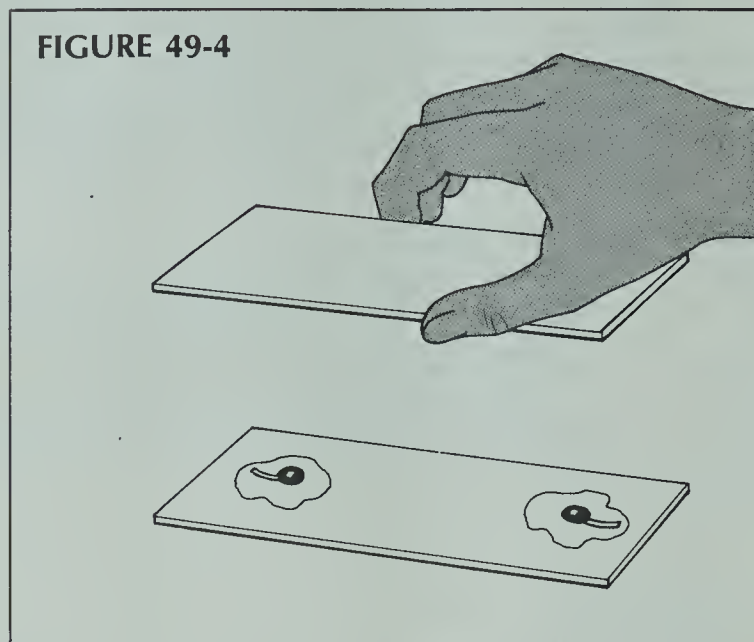


- Add several drops of water to each tip end. Place a second glass slide over the first slide (Figure 49-4). Press down firmly on the top slide with your thumb so that each tip end is slightly squashed.

To prevent thumbprints on the slide, place a piece of paper towel over the top slide before squashing.

- Put the stacked slides on the stage of the microscope keeping both slides together. It may be helpful to use the stage clips to keep the slides from slipping on the stage.

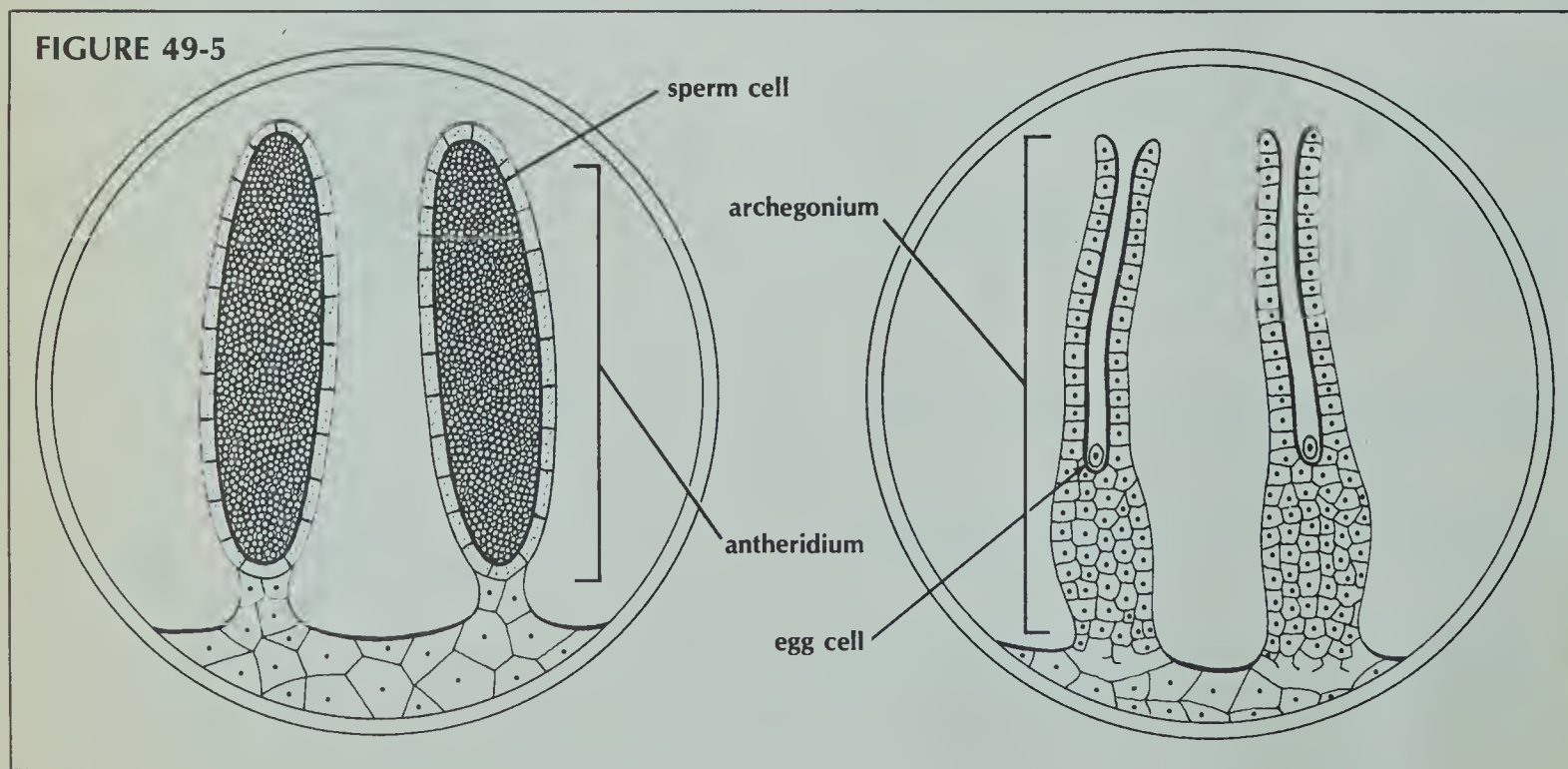
FIGURE 49-4



- Observe the moss tip ends *only under low power magnification*. If high power is desired, carefully remove the top slide and replace it with two coverslips.

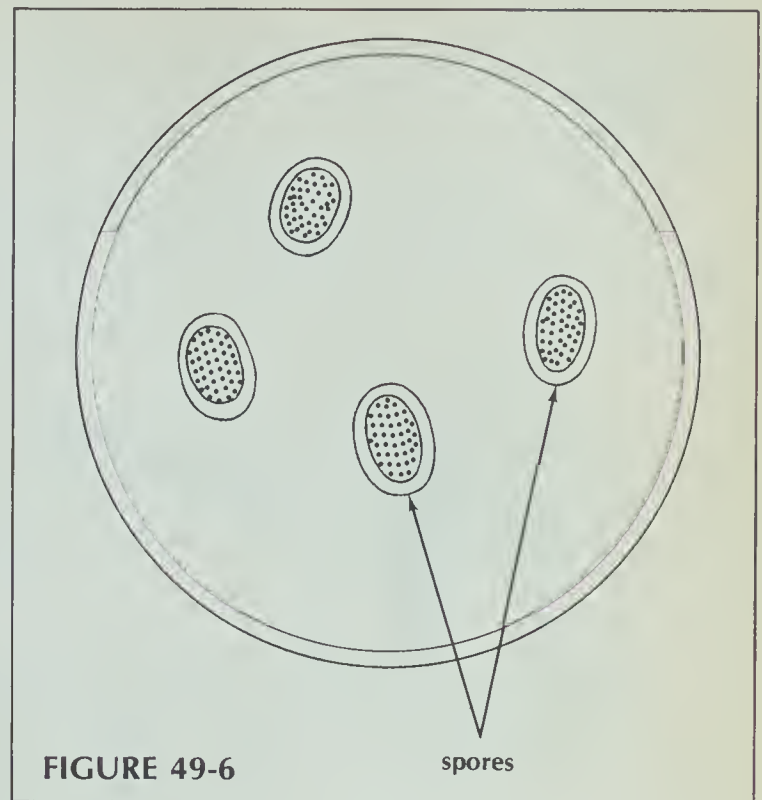
- Identify each of your moss tips as antheridium or archegonium by using Figure 49-5.

FIGURE 49-5



Part C. Reproductive Structure of the Sporophyte

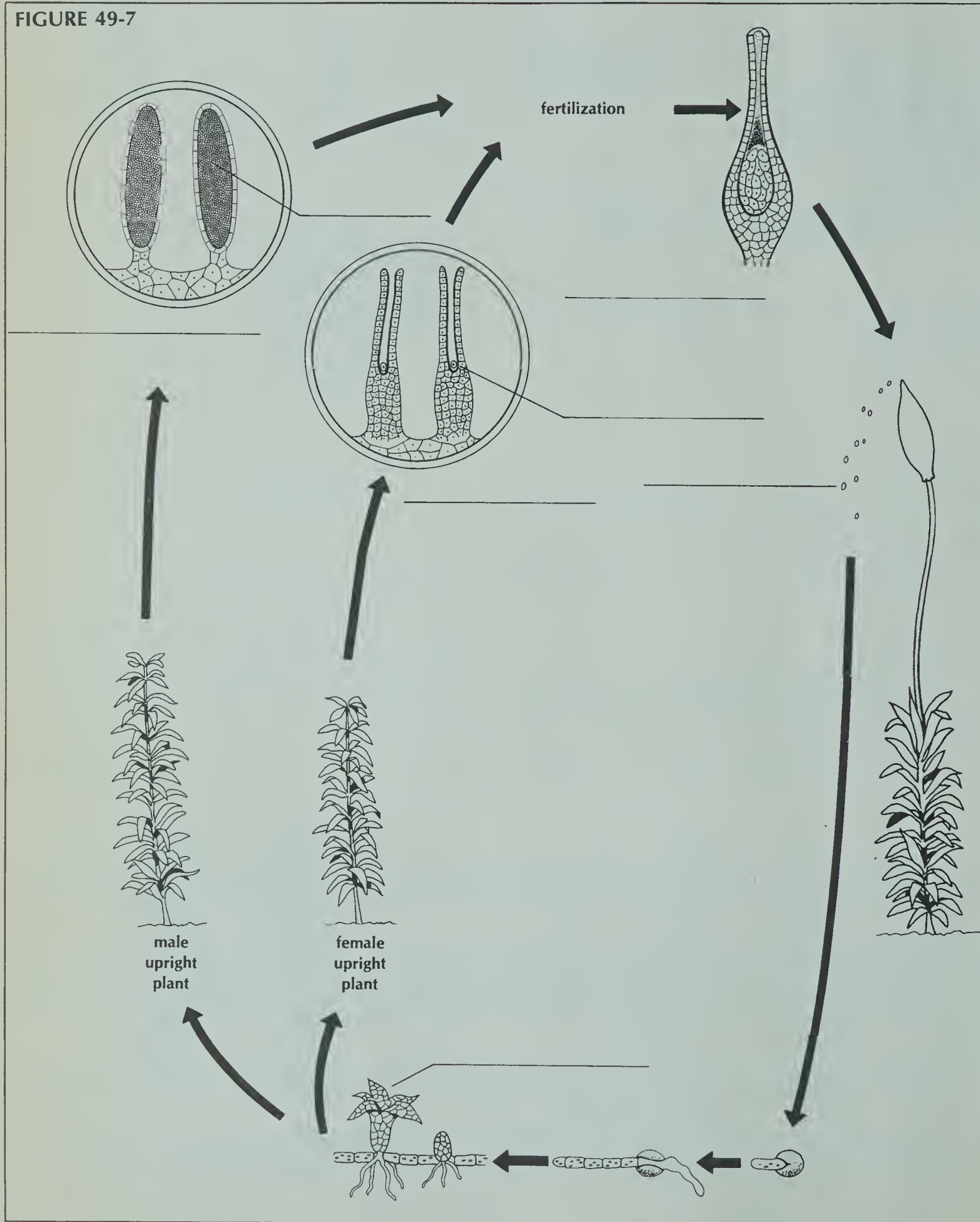
- Obtain a third type of moss plant. This plant has a thin stalk sticking out from the moss tip end.
- Mount the small capsule at the top of the stalk in several drops of water on a microscope slide. Add a second slide as you did for the tip ends and squash the capsule.
- Observe the squashed capsule only under low power magnification of your microscope.
- Identify what you observe by comparing it with Figure 49-6.



Analysis

1. Why do you think moss plants are small? _____
2. Using Figure 49-5 as a guide, explain what type of reproductive cell is formed by
 - (a) a moss plant's antheridium. _____
 - (b) a moss plant's archegonium. _____
3. (a) Are gametophyte moss plants either male or female? _____
(b) What evidence do you have to support your answer? _____
4. The moss plants used to observe male and female reproductive structures are monoploid (haploid) in chromosome number. They form gamete cells. Therefore, they are called gametophyte plants. Is the chromosome number of gamete cells monoploid or diploid? (Consult your text.) _____
5. During reproduction, sperm cells from male moss plants swim through water and fertilize egg cells in the female plant. Fertilization results in a diploid cell. The fertilized egg then grows from the top of the female gametophyte. This growth produces the stalklike plant. Is this plant monoploid or diploid? (Consult your text.) _____
6. Stalklike structures are the sporophyte plants. They produce many spores. These spores are formed by meiosis. Are spore cells monoploid or diploid? (Consult your text.) _____
7. Spores released by moss sporophyte plants fall to the ground and may eventually grow into mature green moss plants. Which generation of moss plant is produced? _____

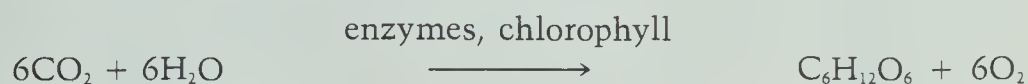
8. The cyclic nature of alternation of generations of mosses is indicated in Figure 49-7. Complete the diagram by adding the following labels: *antheridium*, *spore*, *sporophyte*, *archegonium*, *egg*, *sperm*, *gametophyte*.
9. Explain what is meant by alternation of generations. _____
- _____
- _____



INFLUENCING THE RATE OF PHOTOSYNTHESIS

50

The overall equation for photosynthesis is written as



In words, this says that carbon dioxide combines with water to form glucose and oxygen. This chemical change will take place if chlorophyll, certain enzymes, and light energy are present. Oxygen that is produced in photosynthesis is given off as a gas. If a lot of oxygen is being given off, photosynthesis is occurring rapidly. If little oxygen is being given off, photosynthesis is occurring slowly.

In this investigation, you will

- assemble the equipment needed to measure the rate of photosynthesis in *Elodea*.
- count bubbles of oxygen gas given off by *Elodea* to determine the rate of photosynthesis.
- change the conditions of photosynthesis by altering light intensity and carbon dioxide amount, and determine the effects on photosynthesis rate.
- prepare a bar graph of your collected data, and analyze it.

Materials

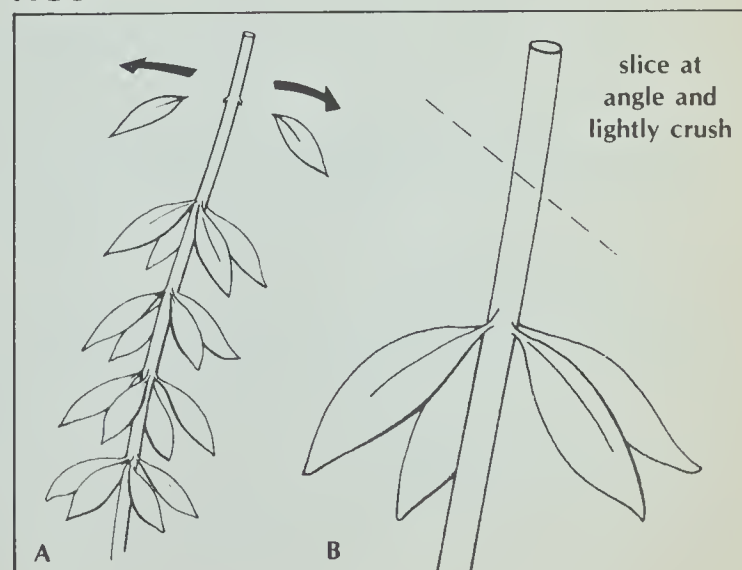
Elodea (water plant)
 test tube (large size)
 water, warm (room temperature)
 sodium bicarbonate powder
 lamp (40 W)
 tape
 razor blade (single-edge)
 metric ruler
 metal stand

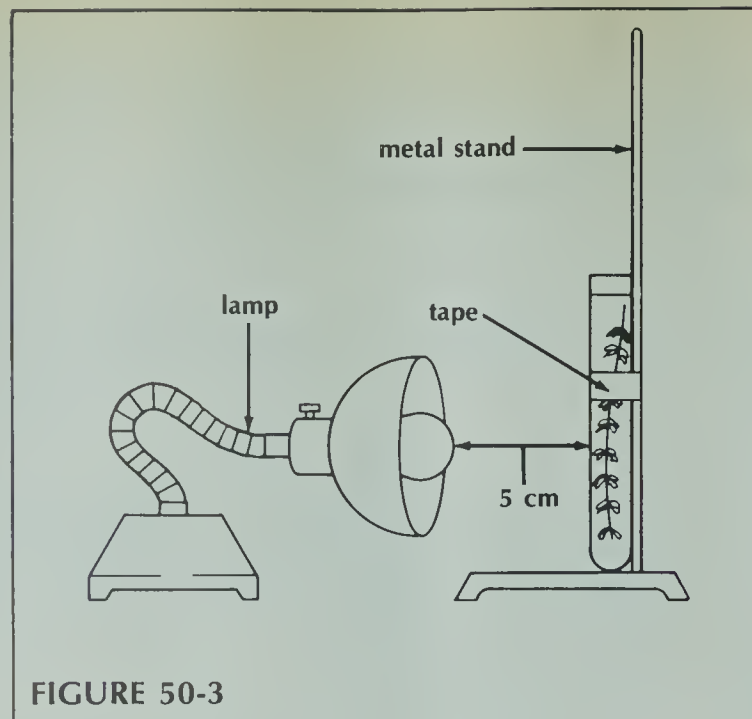
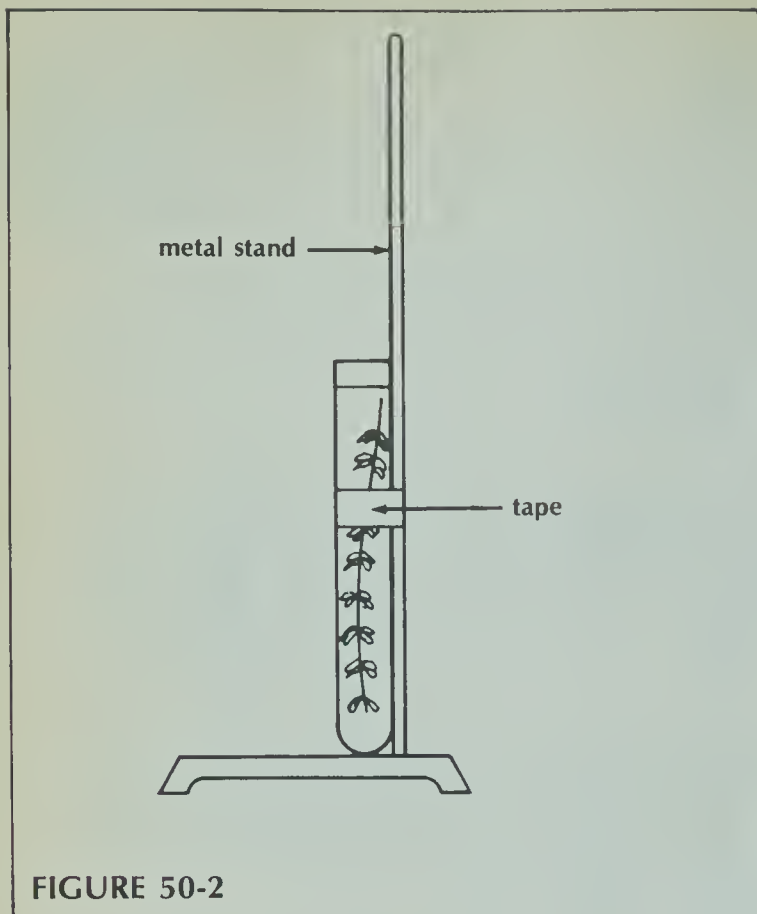
Procedure

Part A. Setting Up the Experiment

- Obtain a sprig of *Elodea*. Remove several leaves from around the cut end of the stem. Slice off a small portion of the stem at an angle and lightly crush the cut end of the stem as shown in Figure 50-1, A and B. **CAUTION:** Blade is sharp. Cut away from your fingers.
- Place the plant into a test tube filled with warm water. Make sure that the cut and crushed end is toward the top of the test tube.
- Secure the test tube to a metal stand with tape as shown in Figure 50-2.

FIGURE 50-1





Part B. Running the Experiment

- Place a 40-W lamp 5 cm from the plant. Note the lamp's position in Figure 50-3. After several minutes, count and record in Table 50-1 the number of oxygen bubbles rising from the cut end of the stem. Count bubbles for five minutes. If bubbles fail to appear, cut off more of the stem and recrush. NOTE: These bubbles will be seen forming at the stem's cut end. The bubbles will break loose and rise to the top of the water within the test tube.

- Run a second five-minute trial. Record and average your results in Table 50-1.

- Move the lamp so it is 20 cm from the plant. After several minutes, count and record bubbles for two five-minute trials. Again, average and record your results in Table 50-1.

- Add a pinch of sodium bicarbonate powder to the test tube. Place the lamp 5 cm from the test tube. After several minutes, record bubbles for two five-minute trials. Average and record your results in Table 50-1.

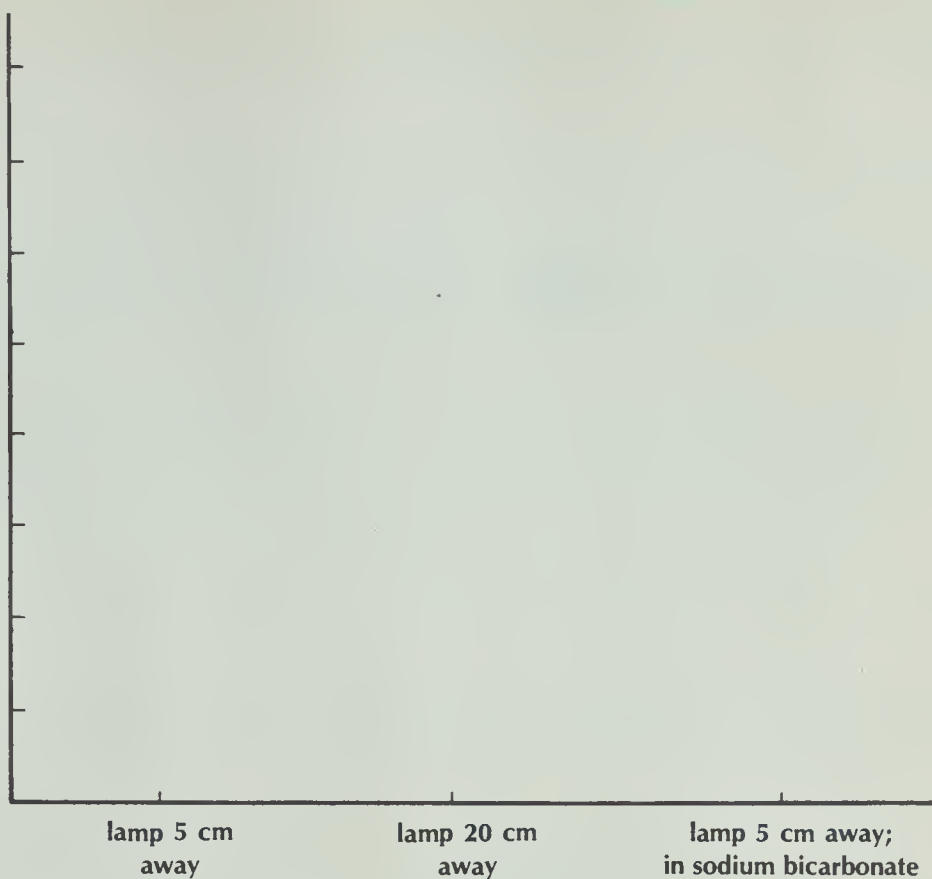
- Prepare a bar graph of your results. Use the average number of bubbles for the vertical (up and down) axis. Use the type of environmental condition for the horizontal (left to right) axis (Figure 50-4). NOTE: You will have to figure out a proper scale to use along the vertical axis.

TABLE 50-1. RESULTS OF THE EXPERIMENT

ENVIRONMENTAL CONDITION	NUMBER OF OXYGEN BUBBLES		
	TRIAL 1	TRIAL 2	AVERAGE
Lamp 5 cm from plant			
Lamp 20 cm from plant			
Plant in sodium bicarbonate; Lamp 5 cm away			

FIGURE 50-4

Average
number of
bubbles
per 5 minutes



Analysis

1. What is being used in this investigation to determine the rate at which photosynthesis is occurring?

2. (a) How did the number of oxygen bubbles (rate of photosynthesis) change as the light source was moved from a distance of 5 cm to 20 cm? _____
(b) What does this change tell you about the amount of light being received by the *Elodea* plant?

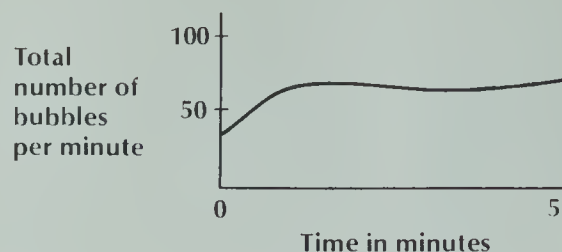
(c) How does the amount of light received by *Elodea* change the rate at which photosynthesis occurs?

3. (a) How did the rate of photosynthesis change when sodium bicarbonate was added to the *Elodea* plant 5 cm from the light? _____

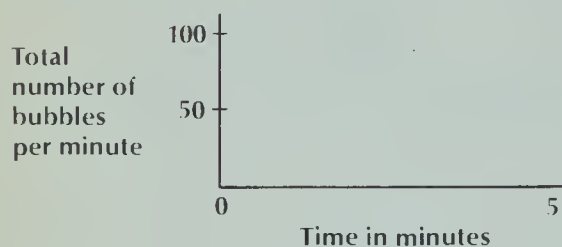
(b) Sodium bicarbonate adds carbon dioxide gas to the water. Why would the addition of sodium bicarbonate increase the rate of photosynthesis? _____

4. A series of line graphs was prepared by a student to help explain experimental results. Figure 50-5 shows the results after the student placed a 40-W bulb 5 cm away from the plant. On each of the following graphs draw a line showing that which is indicated above the graph. In the space beside each graph, explain your reasons for drawing the graph line as you did.

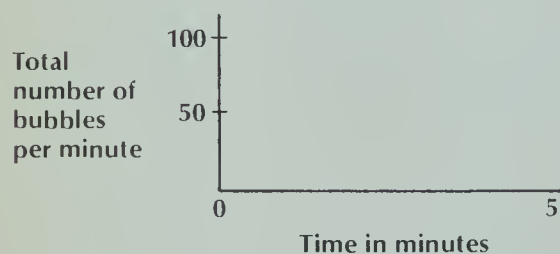
FIGURE 50-5



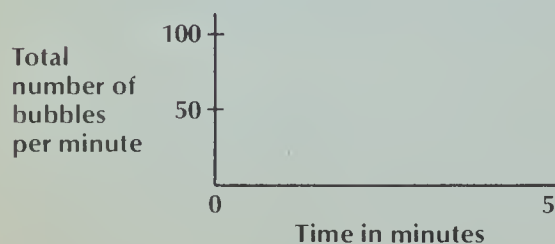
- (a) Show results if an 80-W bulb were placed 5 cm away from the plant.



- (b) Show results if no light at all had been used.



- (c) Show results if a 40-W bulb were placed 20 cm away from the plant.



CHLOROPLAST PIGMENT ANALYSIS

51

When you look at chloroplasts under a microscope or examine a plant leaf, the only color which appears to be present is a green pigment called chlorophyll. However, there are other pigments in a leaf. Yellow and orange pigments, not normally seen, are usually present within chloroplasts.

In this investigation, you will

- remove pigments from spinach by boiling it in water and then heating it in ethyl alcohol.
- separate the pigments from one another by using a technique called chromatography.
- identify the pigments by their colors and positions on the chromatogram.
- determine relative amounts of each pigment.

Materials

test tube holder
filter paper (strip type)
cork
thumbtack
spinach (frozen package that has been defrosted)
solvent
glass rod
water
metric ruler

glass pipette
tweezers
scissors
hot plate
beaker (Pyrex)
ethyl alcohol
beaker (Pyrex) 400 mL
small container
oven mitts—2

Procedure

NOTE: One member of your class or your teacher may wish to prepare the pigment solution (Part A). From this preparation, enough pigment will be made available for the entire class. Each class member will then prepare his/her own chromatogram in Parts B and C.

Part A. Preparing Leaf Pigments

- Fill a 600 mL beaker $\frac{1}{4}$ full of water. Set this beaker on a hot plate. **CAUTION:** *Always be careful when using a hot plate.*
- Bring the water to a boil.
- Place entire package of spinach into the boiling water. Bring to a boil again.
- After several minutes, remove the beaker from the hot plate using the mitts to protect your

hands. Remove the spinach from the water with tweezers and squeeze out all excess water. This step is very important. Then transfer the boiled spinach to a 400 mL beaker containing 80 mL of ethyl alcohol.

- Heat the beaker by placing it onto the hot plate. Leave it on the hot plate for only about 30 seconds or until the alcohol begins to bubble. Remove the beaker using the mitts to protect your hands. Allow the alcohol to cool. Then reheat it several more times. **CAUTION:** *Alcohol is flammable. Do not spill it. If spillage occurs, turn off the hot plate and call your teacher immediately.*

- Remove the beaker from the hot plate. **CAUTION:** *Beaker is hot. Do not touch the beaker with unprotected hands.* Squash the spinach with a glass rod. Reheat and squash until the alcohol solution becomes a dark green color. Enough pigment is now available for the entire class.

Part B. Preparing the Chromatogram Chamber

- Prepare your chromatogram chamber by following these steps.

- *Step 1.* Obtain a strip of filter paper at least 15 cm long.

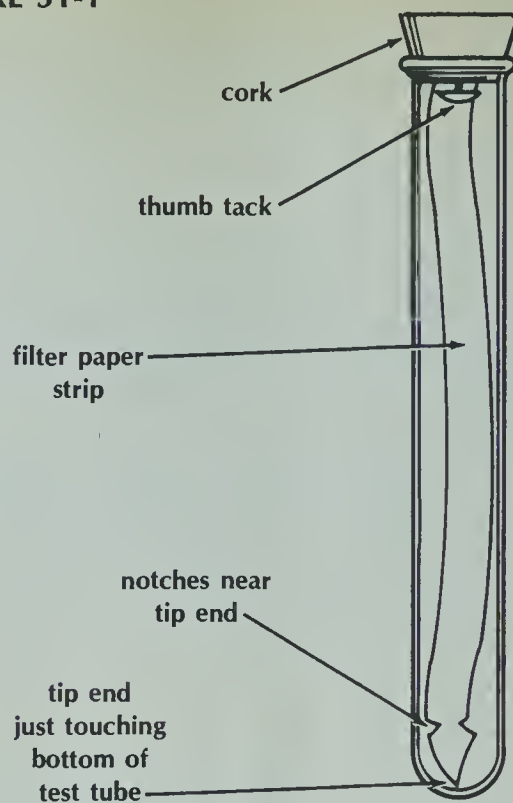
- *Step 2.* Use scissors to taper the bottom of one end of the paper to a point. **CAUTION:** *Always be careful when using scissors.*

- *Step 3.* Cut two small notches about 2 cm from the bottom as shown in Figure 51-1.

- *Step 4.* Attach the filter paper strip to a cork using a thumbtack and position the strip so that when inserted into a test tube, the filter paper tip just touches the bottom. Adjust the height by moving the strip either up or down on the cork.

- *Step 5.* Your completed chamber should look like Figure 51-1.

FIGURE 51-1



Part C. Preparing the Chromatogram

- Prepare your filter paper strip by following these steps.

- *Step 1.* Remove the filter paper strip from the tube and place it on your desk.

- *Step 2.* Add chlorophyll pigment to the paper strip between the two notches as shown in Figure 51-2. Follow the procedure in Step 3.

- *Step 3.* To add chlorophyll to the paper, dip the fine end of a tiny glass pipette into the chlorophyll solution provided. The pipette will fill by itself. Hold it in the chlorophyll solution only for an instant.

- *Step 4.* Touch the pipette to the correct location on the filter paper and quickly remove it. The chlorophyll solution should flow onto the paper. A small circle of solution the size of a pencil is ideal. Use Figure 51-3 as a guide.

- *Step 5.* Allow the spot to dry (about 30 seconds). Then add more pigment solution to the same spot. Make 20 applications of the solution. Allow time for drying between applications.

FIGURE 51-2

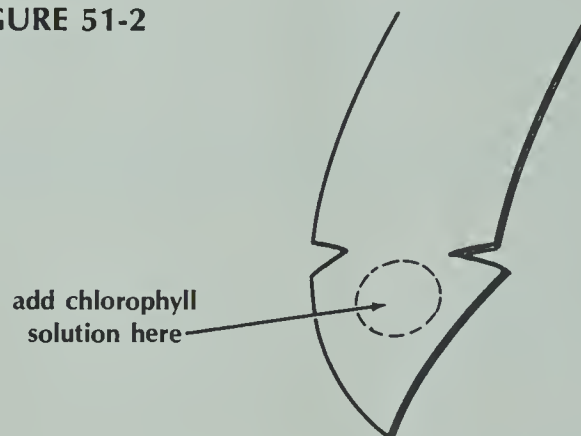
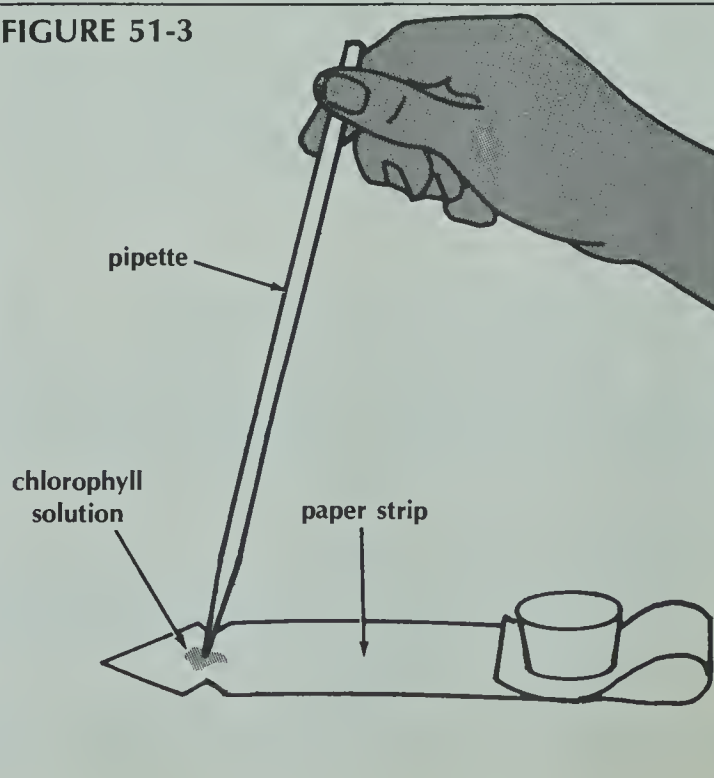


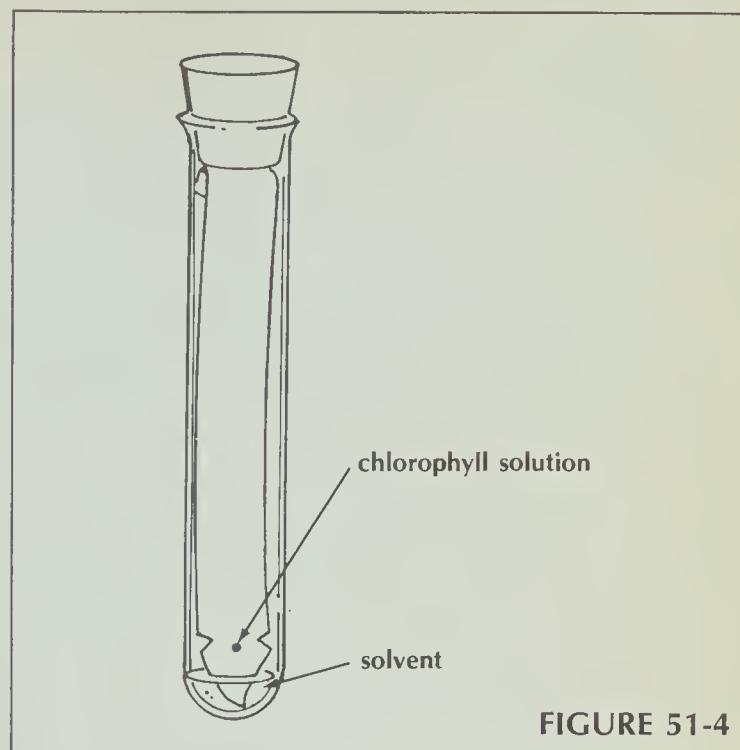
FIGURE 51-3



Part D. Separating the Pigments

CAUTION: SOLVENT IS HIGHLY FLAMMABLE. *Before proceeding, all flames in the laboratory must be extinguished. Make sure the room is well-ventilated. Do not inhale fumes.*

- Add solvent to a height of 0.5 cm in the test tube.
- Carefully place the test tube into the test tube rack.
- Place the filter paper strip into the tube. It is important that the pointed tip dip into the solvent. Do not let the circle of chlorophyll touch the solvent. Use Figure 51-4 as a guide.
- DO NOT move or shake the tube for at least 15 minutes. Remove the paper chromatogram from the test tube when the level of solvent almost reaches the top of the paper strip.
- Examine the chromatogram for the presence of different bands of color. Each color band is a different pigment.



Analysis

1. Describe the appearance of the filter paper strip at the conclusion of the experiment. _____

2. (a) Is chlorophyll composed of one or several pigments? _____
(b) What proof do you have? _____

3. What is the value of chromatography? _____

4. Examine your chromatogram strip. Each color band is a different pigment. Listed in order from top to bottom on an ideal chromatogram are
Carotene—orange in color
Xanthophyll—yellow in color
Chlorophyll *a*—bright green in color
Chlorophyll *b*—a dull or khaki green in color
NOTE: Usually the two chlorophylls are very close to one another.
(a) How many different pigments can be seen on your chromatogram? _____
(b) Name the pigments which are present. _____

(c) Use this outline diagram to draw and label the pigments on your chromatogram.



5. Using the amount of pigments present on your chromatogram,

(a) which pigments are present in the smallest amounts in the leaf? _____

(b) which pigments are present in the greatest amounts in the leaf? _____

6. Use your text (if necessary) to answer the following questions.

(a) In what organelle (cell part) does one find leaf pigments? _____

(b) What is the role of chlorophyll *a*? _____

(c) What is the role of carotene and xanthophyll? _____

7. How might the distribution of leaf pigments differ in a leaf that is dark green in color versus one which is light green in color? _____

8. Many leaves change color in the autumn. How is it possible for this color change to happen? Base your answer on your new knowledge of pigments present in chloroplasts. (HINT: Chlorophyll *a* and chlorophyll *b* are easily broken down by the cooler autumn temperatures.) _____

LEAF ANATOMY

52

Leaves are not all alike in appearance or structure. However, they all have the same function—food production for the plant. Parts within the leaf may help directly or indirectly in the process of food production. Those leaf parts which contain chlorophyll and are green aid directly in food production. Those leaf parts which are not green may aid indirectly by supplying a pathway for needed raw materials to the green cells.

In this investigation, you will

- use a diagram to identify and label the main parts of a lilac leaf cross section.
- observe a privet leaf cross section slide under the microscope.
- prepare and observe the epidermis of an onion leaf.
- describe the function of those leaf parts studied.

Materials

microscope
microscope slide
razor blade (single-edge)
water

coverslip
green onion leaf (leek)
prepared slide of leaf cross section (*Privet*)

Procedure

Part A. A Typical Leaf Cross Section

● Examine the diagram of a cross section of a lilac leaf as it appears under a microscope (Figure 52-1). The cells with small dots are used for photosynthesis. The small dots within these cells represent chloroplasts.

- Identify and label the following leaf structures:
- cutin*—thin, waxy layer which covers the leaf (not composed of cells). Cutin may be

present on both top and bottom or just on the top surface of the leaf. Cutin helps prevent water loss.

- upper epidermis*—single protective layer of cells along top edge of leaf
- palisade layer*—rectangular photosynthetic cells directly below the upper epidermis (normally green)
- spongy layer*—loosely arranged photosynthetic cells below palisade layer (normally green)

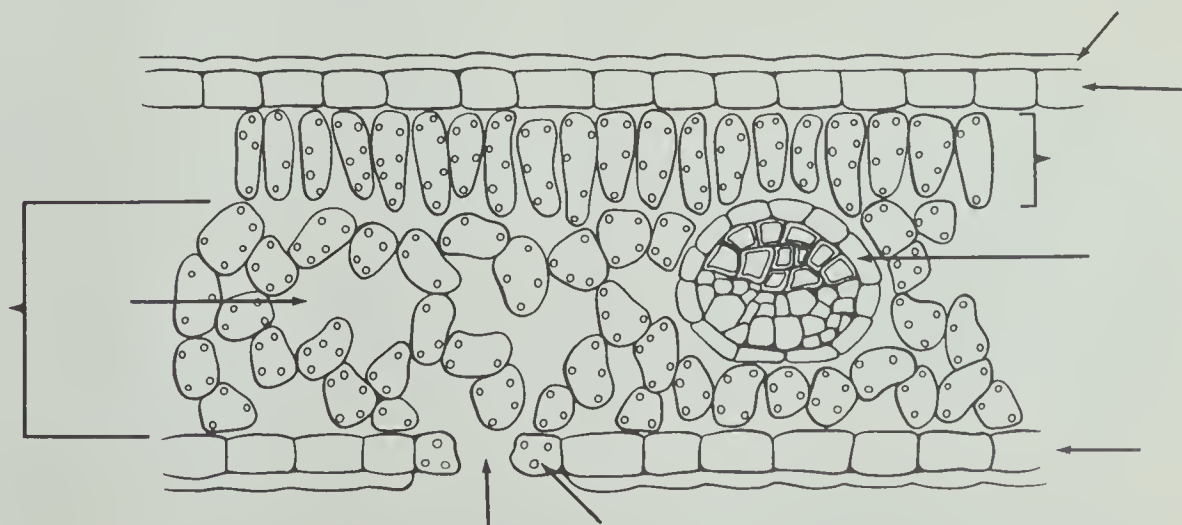


FIGURE 52-1

- (e) *lower epidermis*—thin, protective single layer of cells along bottom edge of leaf
- (f) *stomata*—openings along lower epidermis that allow gas exchange
- (g) *guard cells*—cells surrounding the stomata (green) that control stomata opening and closing
- (h) *veins*—groups of thick-walled cells forming round tubes within the spongy layer, usually surrounded by a single layer of cells forming a tube which transports needed materials throughout the leaf
- (i) *air space*—large empty spaces within spongy layer

- Complete the columns marked "Lilac" in Table 52-1. Check the structures which contain chlorophyll.

TABLE 52-1. STRUCTURES OF LEAVES		
STRUCTURE	LILAC LEAF	PRIVET LEAF
	DOES IT CONTAIN CHLORO-PHYLL?	DOES IT CONTAIN CHLORO-PHYLL?
Upper epidermis		
Lower epidermis		
Palisade layer		
Spongy layer		
Veins		
Guard cells		

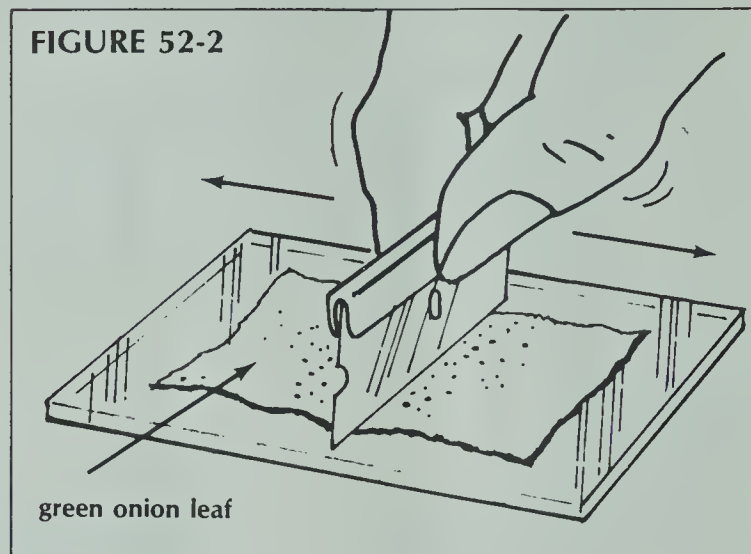
Part B. Privet Leaf Cross Section

- Obtain a prepared slide of a privet leaf cross section. View this slide under low power of your microscope. Locate those leaf structures listed on pages 199 and 200. NOTE: It may be difficult to see chloroplasts within prepared slides of privet. The tissues that contain chloroplasts in lilac are the same for privet.

- Complete the columns marked "Privet" in Table 52-1. Check the structures which contain chlorophyll.

Part C. Observing Stomata

- Place a section of green onion leaf on a microscope slide.
- With a razor blade, slice the leaf section so it lies flat on the slide as shown in Figure 52-2. **CAUTION:** *Blade is sharp. Cut away from fingers. Make sure the original outside surface of the leaf is down.*



- Scraping in one direction only, use a single edge razor blade to gently scrape away the soft cellular material from the inside of the leaf. Use Figure 52-2 as a guide.
- Continue scraping the leaf until only the outer, transparent epidermis remains.

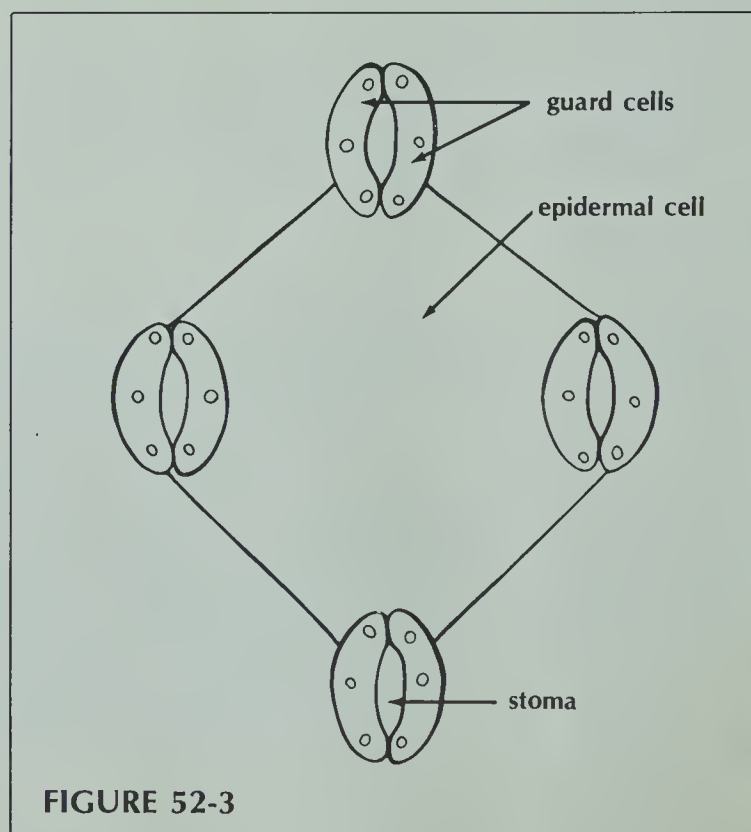


FIGURE 52-3

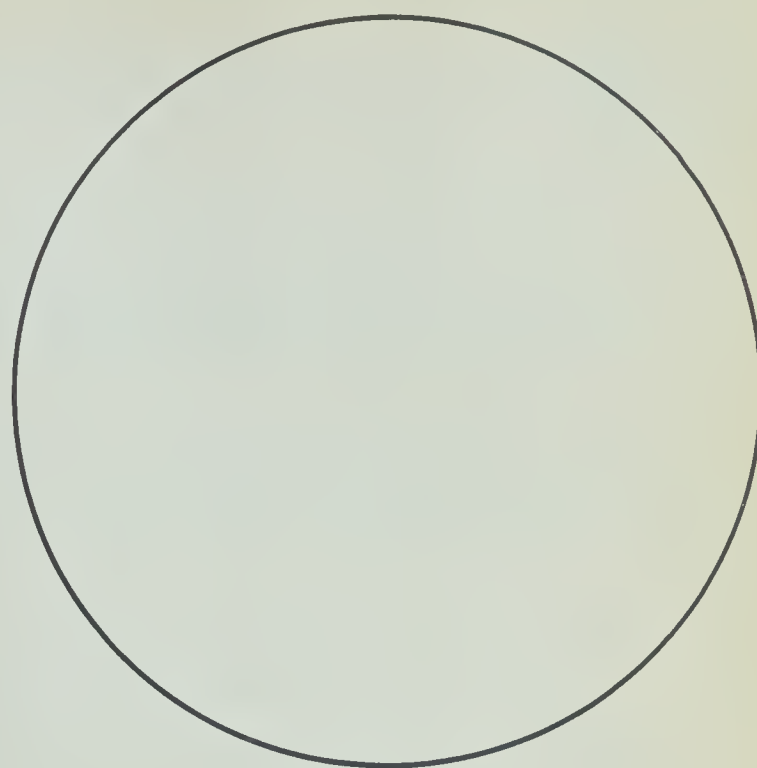
- Prepare a wet mount of the onion epidermis using a few drops of water.

- View the wet mount under low, then high power magnification.

If the epidermis is not clearly visible, there is probably still part of the soft cellular material of the leaf present. If so, repeat the scraping of the leaf with a new green onion section. It may take several tries to obtain only the epidermis.

- Under high power magnification, identify structures using Figure 52-3 and the following descriptions as guides.

- (a) *epidermis cells*—long, diamond-shaped cells
- (b) *guard cells*—half circle-shaped cells
- (c) *stomata*—small spaces or openings between two guard cells
- (d) *chloroplasts*—green dotlike parts within the guard cells



leaf epidermis

- Use the space provided to diagram what you see under high power. Label *guard cell*, *stomata*, *chloroplasts*, *epidermal cell*.

Analysis

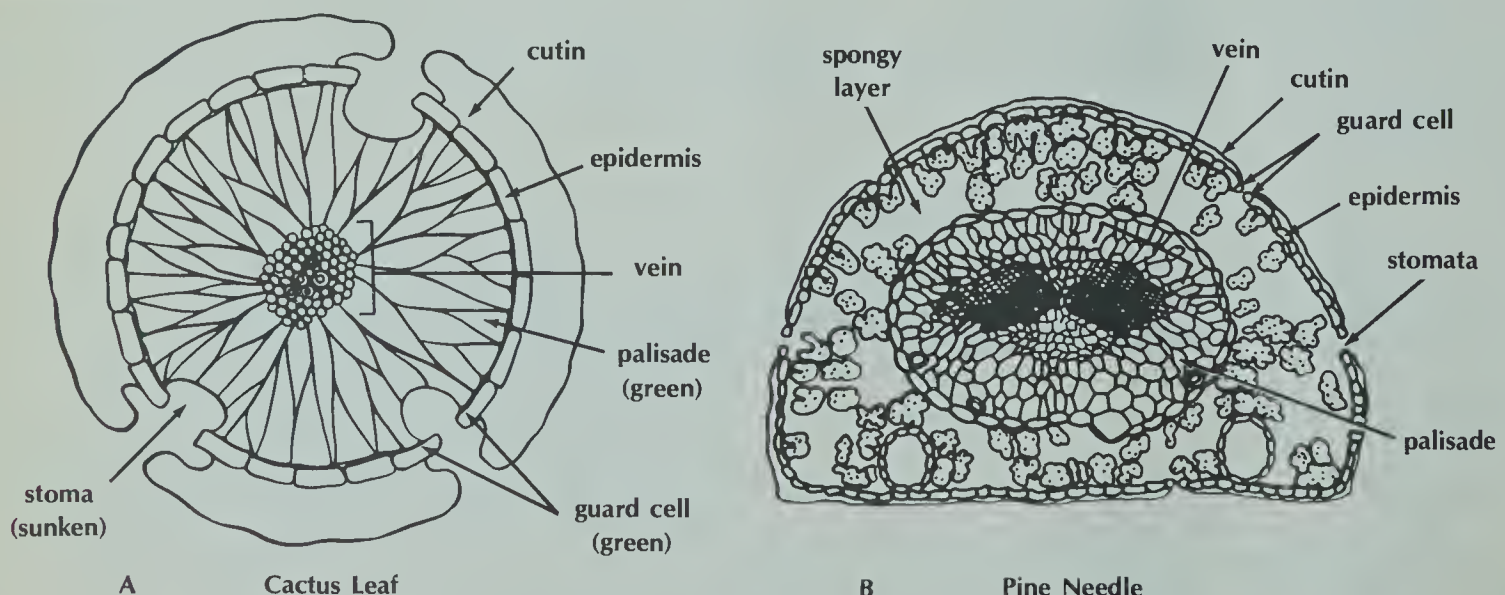
1. What is the major function of leaves? _____
2. (a) What pigment is present in certain leaf tissues that allows a leaf to carry on its major function?

- (b) What color is this pigment? _____
3. List all tissues or cells observed or described in this investigation that allow a leaf to carry on its major function. _____

4. What is the function of each of the following tissues or structures? (See Part A.)
 - (a) epidermis _____
 - (b) veins _____
 - (c) guard cells _____
 - (d) stomata _____
 - (e) palisade layer _____

- (f) spongy layer _____
- (g) cutin _____
5. A cactus leaf cross section diagram is shown in Figure 52-4A. The leaf of a cactus is actually a needle. This diagram is quite different from the lilac leaf drawing (Figure 52-1). Which leaf, cactus or lilac,
- (a) has thicker cutin? _____
- (b) has deep set stomata in its cutin? _____
- (c) has both spongy and palisade layers? _____
- (d) has a flat shape? _____
- (e) has air spaces within the leaf? _____
6. Consider where cacti live. How might
- (a) thick cutin give an adaptive advantage? _____
- _____
- (b) no spongy layer give an adaptive advantage? _____
7. A pine leaf cross section is shown in Figure 52-4B. Which leaf, pine or lilac
- (a) has thicker cutin? _____
- (b) has deep set stomata in its cutin? _____
- (c) has both spongy and palisade layers? _____
- (d) has a flat shape? _____
- (e) has air spaces within the leaf? _____
8. (a) List two ways in which pine and cactus leaves are similar. _____
- (b) List two ways in which pine and cactus leaves differ. _____

FIGURE 52-4



Upper and lower epidermis are not identified because leaves are round.

COMPARING DORMANT AND GERMINATING SEEDS

53

Seeds that are purchased for planting are viable (alive). However, they show no signs of any life processes. Scientists refer to seeds in this condition as being dormant. When dormant seeds are soaked in water, they respond by quickly showing evidence of life processes. Such seeds are said to be germinating.

One of the life processes carried on by seeds is respiration. When respiration occurs, a seed takes in oxygen gas from the air and gives carbon dioxide off into the air in about equal amounts. A dormant seed carries on the process of respiration very slowly. Germinating seeds carry on this process rapidly.

In this investigation, you will

- prepare respiration chambers to measure the amount of oxygen used by seeds.
- compare the rate of respiration occurring in dormant and germinating seeds.
- measure and record the height to which water rises in each chamber to indicate the amount of oxygen used by each seed type.
- predict the amount of oxygen used up by seeds in various experimental situations.

Materials

test tubes—3
soaked bean seeds
dry bean seeds
cotton
metric ruler
soda lime

small beaker
water, colored
spatula
masking tape and pen (or glass marking pencil)
rubber band

Procedure

- Place five dry dormant seeds into a test tube.
- Add a small cotton plug just above the beans. Do not pack the cotton too tightly but tight enough so that seeds cannot fall out when the tube is turned upside down.
- Add about a centimetre of soda lime (a carbon dioxide gas absorber) to the test tube. **CAUTION:** Do not handle soda lime with bare hands.
- Insert a second cotton plug over the soda lime as shown in Figure 53-1.
- Use tape or a marking pencil to label the test tube "dormant." Place the label toward the round or bottom end of the test tube.
- Prepare a second tube in a similar manner. However, put in five soaked germinating seeds instead of the five dormant beans. Label this tube "germinating."

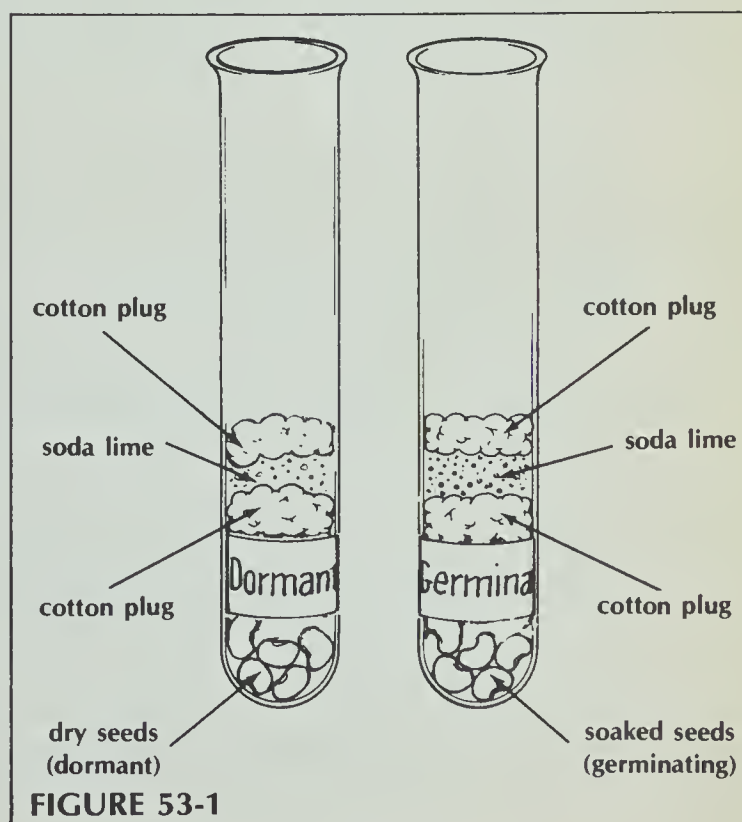


FIGURE 53-1

- Prepare a third tube with no seeds. Add about a centimetre of soda lime and a small cotton plug just above the soda lime.
- Turn the tubes upside down and place them into a small beaker that contains 30 mL of colored water. A rubber band placed around all three tubes will prevent their tipping over.
- With a ruler, measure in millimetres the height to which the colored water rises in each test tube (Figure 53-2). Look carefully. Measure the water level in the test tube, not the beaker.
- Record the height for each test tube in Table 53-1. Record the height as 0 mm if water does not move into a test tube.
- Allow all test tubes to remain undisturbed for at least 24 hours.
- After 24 hours, measure and record the new height of water inside each test tube. DO NOT move the beaker or remove the test tubes from the beaker until you have measured the height of water within each test tube.

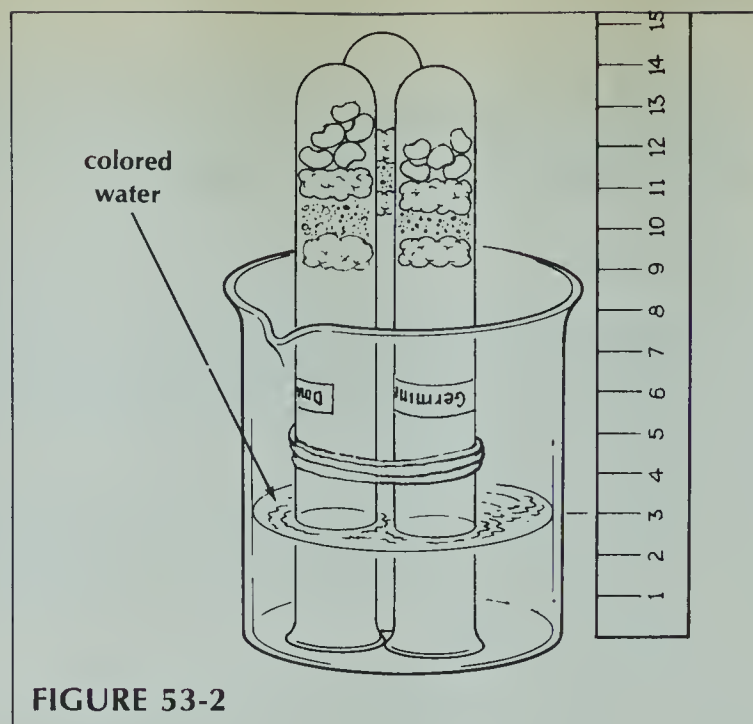


FIGURE 53-2

- Calculate the difference in water height from start to end by subtracting the height of water in each tube at the start from the height of water in each tube after 24 hours. Record this amount in the last column of Table 53-1.

TABLE 53-1. HEIGHT OF WATER IN TEST TUBES

TUBE CONTENTS	HEIGHT OF WATER AT START	HEIGHT OF WATER AFTER 24 HOURS	DIFFERENCE IN WATER HEIGHT
Dormant seeds			
Germinating seeds			
No seeds			

Analysis

- What is probably trapped within each tube turned upside down in the water? _____
 - What prevents water from moving into each tube at the start of the experiment? _____
- If air within a tube is used, water will rise within the tube to replace the missing air.

 - Which tube shows the most evidence of air being used in 24 hours? _____
 - What is the evidence? _____
 - What specific gas found in air probably is being used? _____

3. What life process is responsible for the uptake or using of this gas? _____

4. (a) Which seed type, dormant or germinating, carries on this process at a faster rate? _____
(b) What is the evidence? _____

5. What does the tube containing no seeds show? _____

6. Soda lime is a chemical which absorbs or removes carbon dioxide from air.
(a) Recalling that seeds use oxygen gas and release carbon dioxide, predict the level of water 24 hours later in all tubes if no soda lime is used. _____
(b) Explain. _____

7. A seed contains a food supply. This food is used during respiration.
(a) Which type of seed, dormant or germinating, carries on respiration at a slower rate? _____
(b) What experimental evidence do you have to support your answer? _____
(c) Which type of seed, dormant or germinating, would use food at a slower rate? _____
(d) Explain why using food slowly may be an advantage to the survival of the plants. _____

8. Suppose you place 20 germinating bean seeds into one test tube and add soda lime. Into a second tube, you place 10 germinating bean seeds along with soda lime. You then invert both tubes into a beaker of water. Complete Table 53-2 by providing what you might expect in measurements for the rise in water 24 hours later.

TABLE 53-2.	
	HEIGHT OF WATER 24 HOURS LATER
20 germinating seeds	
10 germinating seeds	

9. Give your reasons for the measurements given in Table 53-2. _____

10. Suppose you place 20 germinating bean seeds into one test tube with soda lime. Into a second tube you place 20 germinating bean seeds but no soda lime. You then invert both tubes into a beaker of water. Complete Table 53-3 by providing what you might expect in measurements for the rise in water 24 hours later.

TABLE 53-3.	
	HEIGHT OF WATER 24 HOURS LATER
20 germinating seeds with soda lime	
20 germinating seeds with no soda lime	

11. Give your reasons for the measurements in Table 53-3. _____

12. Assume that you boil some germinating seeds for 30 minutes in water. Place these boiled seeds into a test tube with soda lime. Prepare a second tube with unboiled germinating seeds and soda lime. Invert both tubes into water. Complete Table 53-4 by providing what you might expect in measurements for the rise in water 24 hours later.

TABLE 53-4.	
	HEIGHT OF WATER 24 HOURS LATER
Boiled germinating seeds with soda lime	
Germinating seeds with soda lime	

13. Give your reasons for the measurements in Table 53-4. _____

14. One hundred dormant seeds are placed into a tube with soda lime. A second tube containing soda lime only is prepared. Both tubes are inverted in a beaker of water. Complete Table 53-5 by providing what you might expect in measurements for the rise in water 10 days later.

TABLE 53-5.	
	HEIGHT OF WATER 10 DAYS LATER
Dormant seeds with soda lime	
Soda lime only	

15. Give your reasons for the measurements in Table 53-5. _____

ROOTS AND STEMS

54

Plant roots and stems are living tissues that clearly show close relationships between their function and structure.

Plant roots absorb water and minerals from the soil and transport them to the stem. Roots also function in food storage and anchor plants into the soil.

Major stem functions include plant support as well as a pathway for transporting food and water. The woody stem of a tree also provides a permanent record of the tree's age.

In this investigation, you will

- (a) identify and label root tissues.
- (b) learn the function of these root tissues.
- (c) identify and label tree tissues of a 1, 2, and 3-year-old stem.
- (d) learn the function of these stem tissues.

Materials

parsnip root
razor blade (single-edge)
microscope slide
coverslip

water
microscope
iodine stain

Procedure

Part A. Root Anatomy

Your teacher has sliced some rings of parsnip root. They were prepared as shown in Figure 54-1.

● Examine your ring. Note that you can see two specific areas. These areas are marked in Figure 54-1 as A and B.

● Prepare your root tissue for microscopic viewing as follows:

FIGURE 54-1

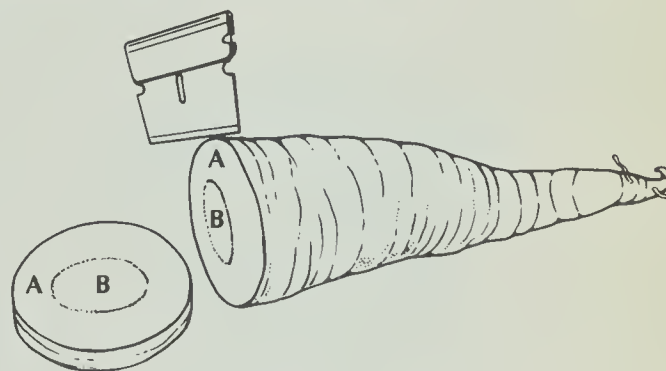
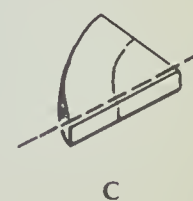
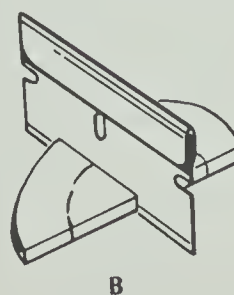
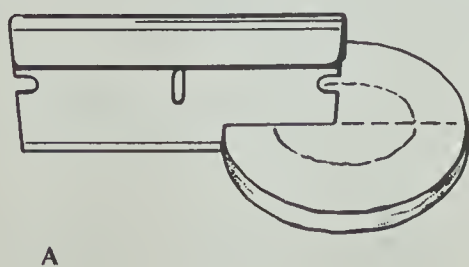


FIGURE 54-2



- *Step 1.* Cut root ring in half (Figure 54-2A). **CAUTION:** Blade is sharp. Cut away from fingers.

- *Step 2.* Cut root ring in half again in the opposite direction (Figure 54-2B).

- *Step 3.* Slice off as thin a section as possible from the side of the root as shown (Figure 54-2C).

- Place your slice onto a microscope slide. Add iodine stain and a coverslip. **CAUTION:** Iodine is poison. If spillage occurs, wash with water and call your teacher immediately.

- Examine the slide under low power magnification of your microscope. Move the slide across the field of view so that all areas of the root are observed.

- Look for two distinct kinds of cells. One type of cell will appear very long, with a railroad track appearance. These are transporting cells. The other cells are somewhat rounded or squared cells packed closely together. They are smaller than transporting cells. Starch grains should appear blue from the iodine stain in these cells. These are storage cells.

- In Table 54-1 diagram a few of the different cell types in areas A and B as seen under low power.

TABLE 54-1. PARSNIP ROOT SLICE UNDER LOW POWER MAGNIFICATION	
Area A	Area B

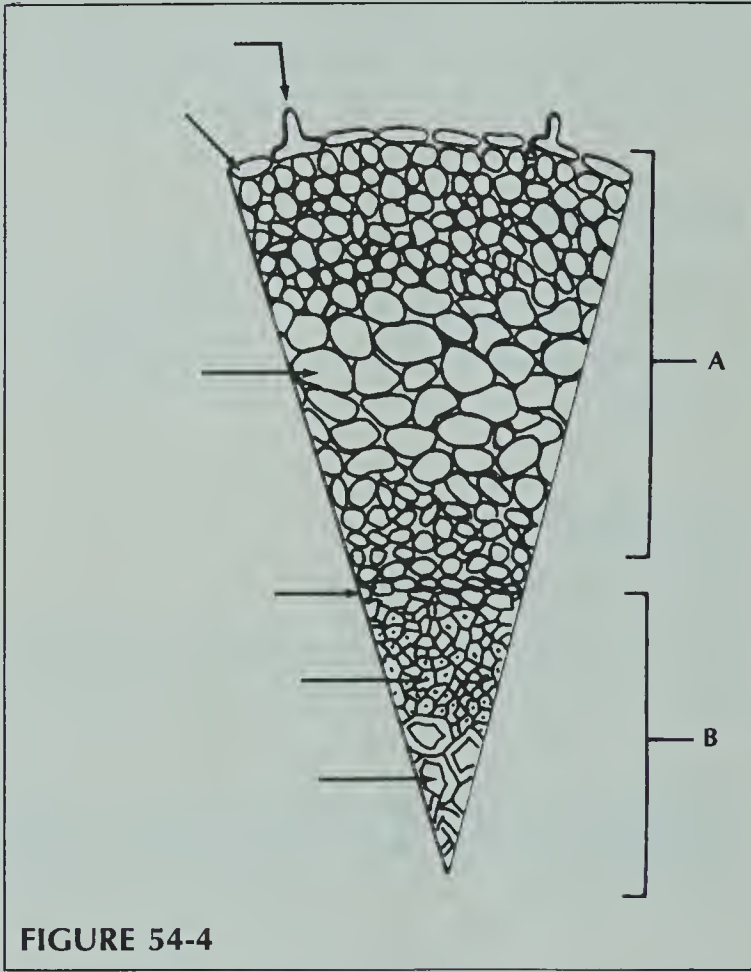
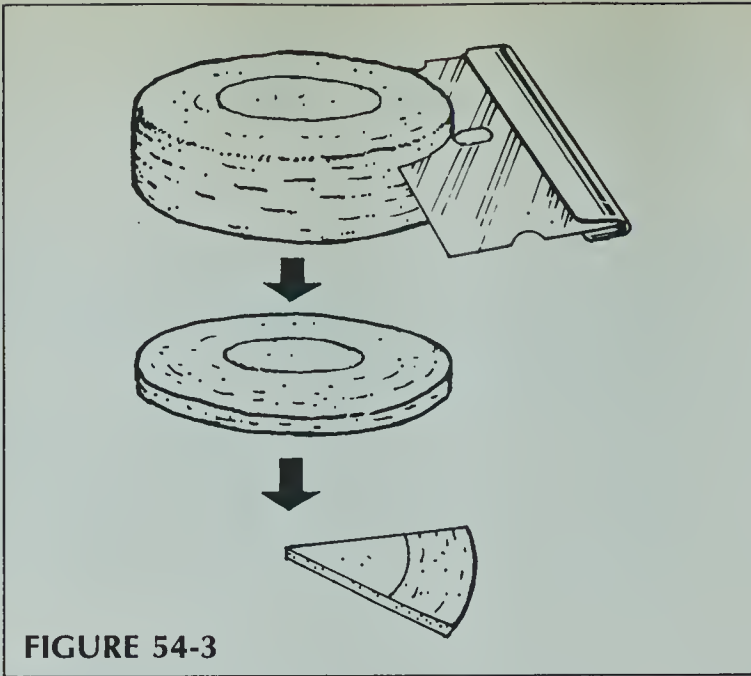


TABLE 54-2. ROOT AREAS AND THEIR FUNCTIONS			
AREA	NAME	DESCRIPTION	FUNCTION
A	Cortex	Widest area of root	
B	Central cylinder	Center area of root	

• Based on your observations and diagrams, complete Table 54-2 by giving the functions for these two areas. Note that the table gives the names for these areas.

• Figure 54-4 shows a slice of parsnip root as it appears under a microscope. Instead of its being a side view as seen before under the microscope, this

is a cross section or top view looking down. It was prepared as shown in Figure 54-3.

• Identify and label the root structures in Figure 54-4 by using the descriptions in Table 54-3. Areas A and B (cortex and central cylinder) are marked for you.

TABLE 54-3. ROOT PARTS AND FUNCTIONS

TISSUE	DESCRIPTION
Xylem	Thick-walled cells in Area B at tip end of slice; part of central cylinder, transports water.
Phloem	Thin-walled cells in Area B found in groups next to xylem; part of central cylinder, transports food.
Epidermis	Outermost layer of root; protective covering; one cell thick.
Root hairs	Fingerlike projections on some epidermal cells; increases surface area for water absorption.
Endodermis	Single layer of cells, ringlike, separating Area A from Area B; protective covering.
Cortex	Widest area of root; stores food; makes up most of Area A.

Part B. One-Year-Old Tree Stem

Figure 54-5 shows how a cross section of a tree stem is made.

• Examine the diagram of the cross section of a one-year-old tree stem as viewed through a microscope (Figure 54-6).

• Study the descriptions of stem tissues in Table 54-4. Then label each tissue indicated by a line in Figure 54-6.

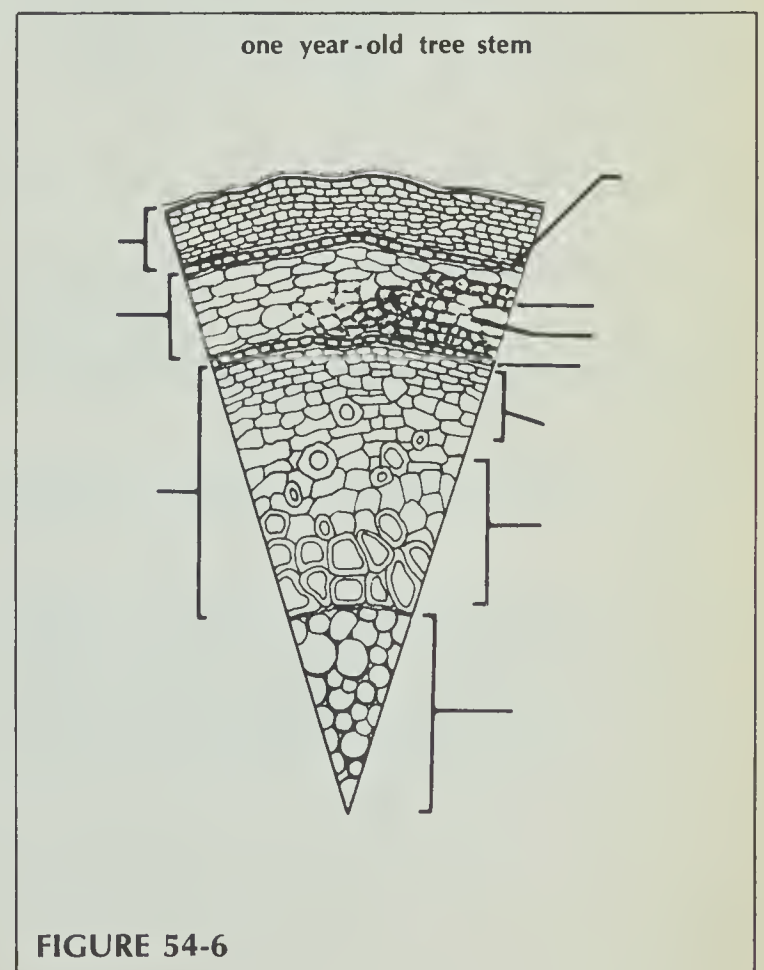
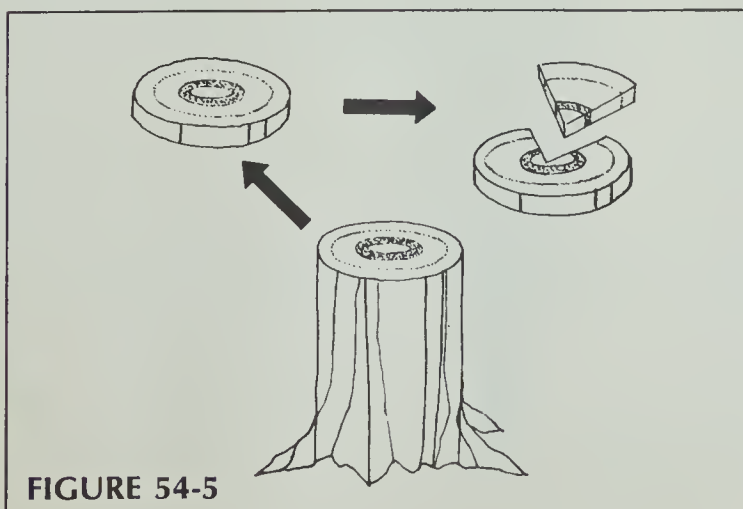


TABLE 54-4. STEM TISSUES

TISSUE	DESCRIPTION
Cork	Outermost layer, about eight cell layers thick, protects against water loss.
Cork cambium	Single layer of cells just inside the cork layer, produces new cork cells.
Cortex	First layer inside cork cambium, about ten cells thick, cells larger and with thinner cell walls than cork cells, stores food.
Pith	Tissue at center of stem (pointed end of wedge diagram), large thin-walled cells, stores food.
Xylem (a) Spring xylem (b) Summer xylem	Thick layer of cells next to pith, widest layer of cells in stem, transports water and supports stem. Portion of xylem with large cells, produced in spring. Portion of xylem with small cells, produced in summer.
Vascular cambium	Single layer of cells at top edge of xylem, produces new xylem and phloem cells.
Phloem	Groups of thin-walled cells, inside cortex, transports food.
Bast fibers	Groups of thick-walled cells, no hollow center visible, surrounds phloem, supports stem.

Part C. Two-Year-Old Tree Stem

- Compare the diagram of a two-year-old tree stem (Figure 54-7) with that of the one-year-old stem.

1. How many bands or sections of xylem are present in

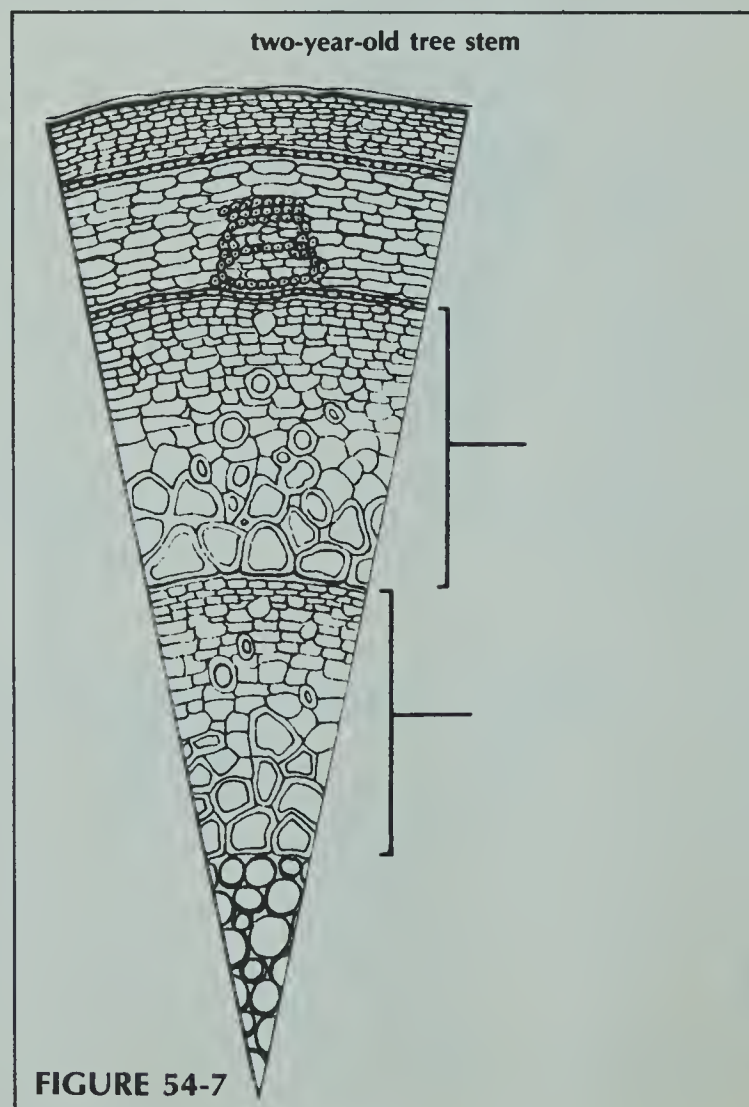
(a) a one-year-old tree stem? _____

(b) a two-year-old tree stem? _____

- Note that the difference in size of spring and summer xylem cells creates a line which separates one year of xylem from the other.

2. Which xylem, spring or summer, has larger cells? _____

3. Give a possible reason cell diameter may differ between spring and summer xylem. (HINT: Think in terms of available water. Much water results in good growth of cells. Little water results in slower growth.) _____



4. Each year, a new band of xylem tissue is formed. This band is called an annual ring and includes both spring and summer xylem. Which tissue

forms this band? (Consult Table 54-4.) _____

5. The new band of xylem forces the older band (last year's) in toward the stem's center. To which stem tissue is the oldest ring or band of

xylem found closest? _____

- Label Figure 54-7 which shows a two-year-old stem cross section. Use these labels: *first year xylem* (oldest), *second year xylem* (youngest).

Part D. Three-Year-Old Tree Stem

- Compare the diagram of a three-year-old tree stem (Figure 54-8) with that of the one- and two-year-old stems.

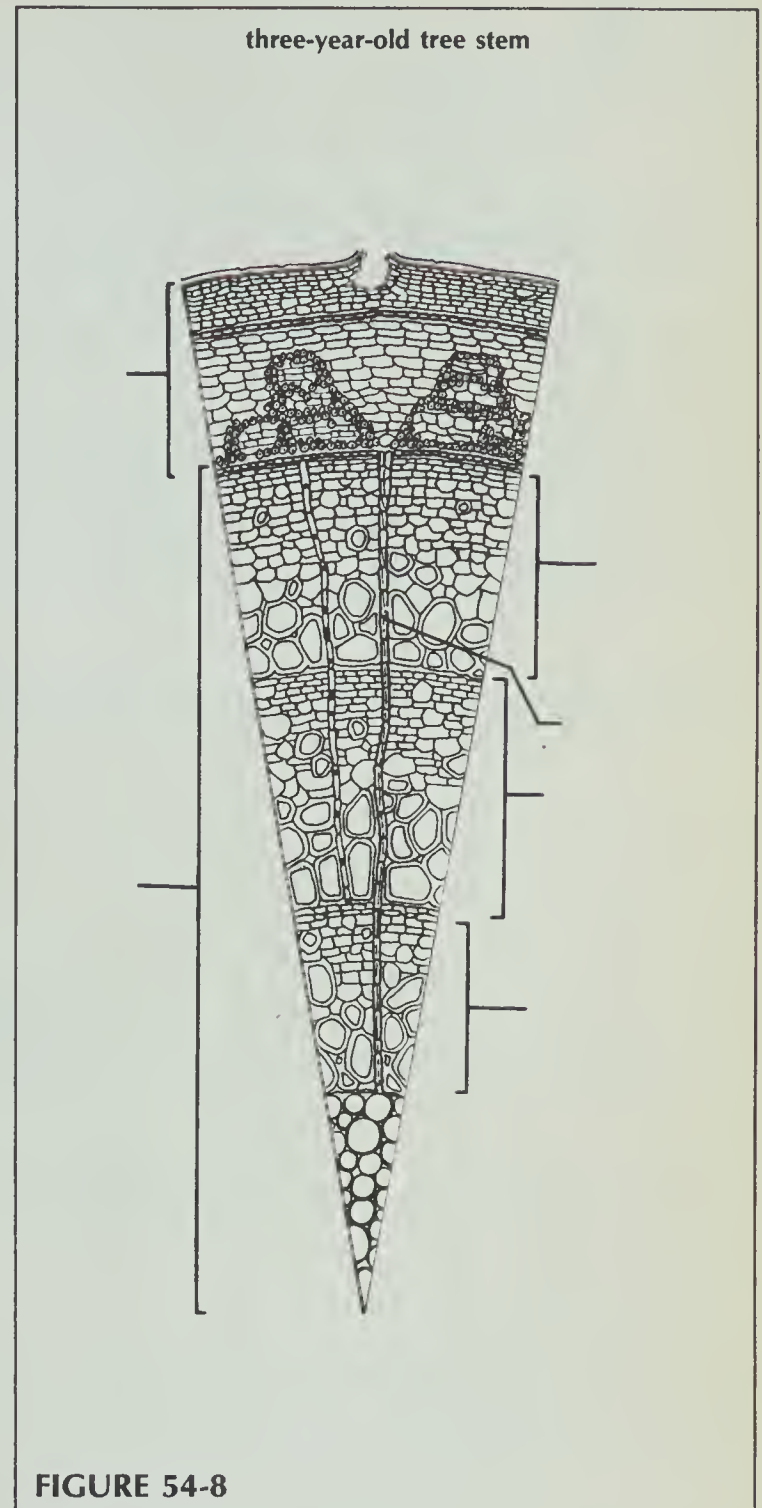
- Label the diagram of the three-year-old tree stem for the tissues indicated. Label each band of xylem as *first year xylem* (oldest), *second year xylem*, and *third year xylem* (youngest) using the label lines along the right side of Figure 54-8.

- Label the areas indicated at the left of Figure 54-8 using these terms:

bark—all tissue from cork through vascular cambium

wood—all tissue from youngest xylem band through pith

vascular ray—a narrow, one cell thick tissue which extends through the xylem



Analysis

1. How is the shape and function of the central cylinder of a root similar to water pipes or blood vessels? _____

2. How is the shape and function of the cortex of a root similar to cabinets or closets? _____

3. Using Tables 54-3 and 54-4, complete the following chart. Write the tissues in roots and stems which carry out the function listed in column one of the chart.

FUNCTION	ROOTS	STEMS
Protection		
Food Storage		
Transport food or water		
Absorb water from soil		—
Produce new tissue	—	
Support stem	—	

4. (a) Name the two major cell types which make up the central cylinder of a root. _____

- (b) What does each cell type transport? _____

5. Skin is called a dermis. The prefix *epi-* means outside. *Endo-* means inside.

- (a) What are the functions of epidermis and endodermis? _____

- (b) Are these two cell layers properly named for their location and function in a root? _____

- (c) Explain. _____

6. How is the structure of bast fibers adaptive to their function? (HINT: They are very thick.)

7. A thin, waxy layer (cutin) is present along the edge of the tree's cork. How might this layer aid cork in its function? _____

8. (a) How many bands or sections of xylem are present in a three-year-old tree stem? _____

- (b) Does a tree stem form a new band of xylem during each year of growth? _____

- (c) How can a tree's age be determined? _____

9. Annual rings will vary in thickness due to factors in the environment which influence growth. What kinds of factors during a year might influence growth? _____

INFLUENCE OF HORMONES ON PLANT GROWTH

55

Living systems produce many chemicals which influence or regulate specific cell processes in organisms. One type of these chemicals are called hormones. Plant hormones include auxins and gibberellic acid. These hormones control plant processes such as stem cell elongation. They also direct roots to grow down toward gravity and stems to grow up away from gravity.

In this investigation, you will

- compare the growth rate of young bean plants grown in water (control) to those grown in gibberellic acid (a growth stimulating hormone).
- prepare a graph of your data showing how growth differs when a hormone is added to one bean plant.
- compare the direction of growth shown by young corn roots and stems when positioned in different orientations to gravity.

Materials

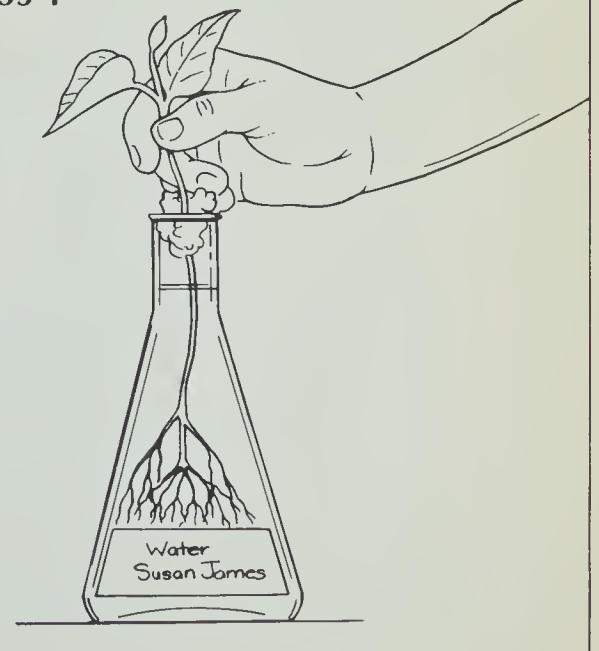
- | | |
|---|-----------------------|
| bottles or flasks—2 | paper towels |
| cotton | stapler |
| bean plants (about 10 days old)—2 | plastic bag |
| gibberellic acid solution (1:1 000 000) | corn seeds—4 (soaked) |
| labels | straight pins |
| metric ruler | bowl or shallow dish |
| cardboard | |

Procedure

Part A. Effects of Hormones on Growth

- Obtain two young bean plants from your teacher.
- Fill one of your flasks with water. Label the flask with your name and the word "water."
- Fill the other flask with gibberellic acid solution. Label this flask with your name and "gibberellic acid."
- Place one bean plant into each bottle. Hold the plants in place by packing cotton into the bottle opening. Be careful that you do not break the bean stems or roots. Use Figure 55-1 as a guide.

FIGURE 55-1



- Measure the heights in millimetres of each plant. Measure the height as the distance of the stem from the first pair of true leaves to the tallest structure of the plant (Figure 55-2). If the plant stem droops, hold the stem upright while measuring. Record these heights in Table 55-1 for day zero.
- Place both plants in the light. Replace any loss of water or gibberellic acid solution due to evaporation over the next ten days.
- Measure the height of each plant daily (or as often as class meets) for a period of ten days.
- Record the heights in Table 55-1.
- Each day, determine and record in Table 55-1 the total change in height of your two plants. For example, if your plant stem measures 2 mm on day one and 10 mm on day two, the change in height is 8 mm.

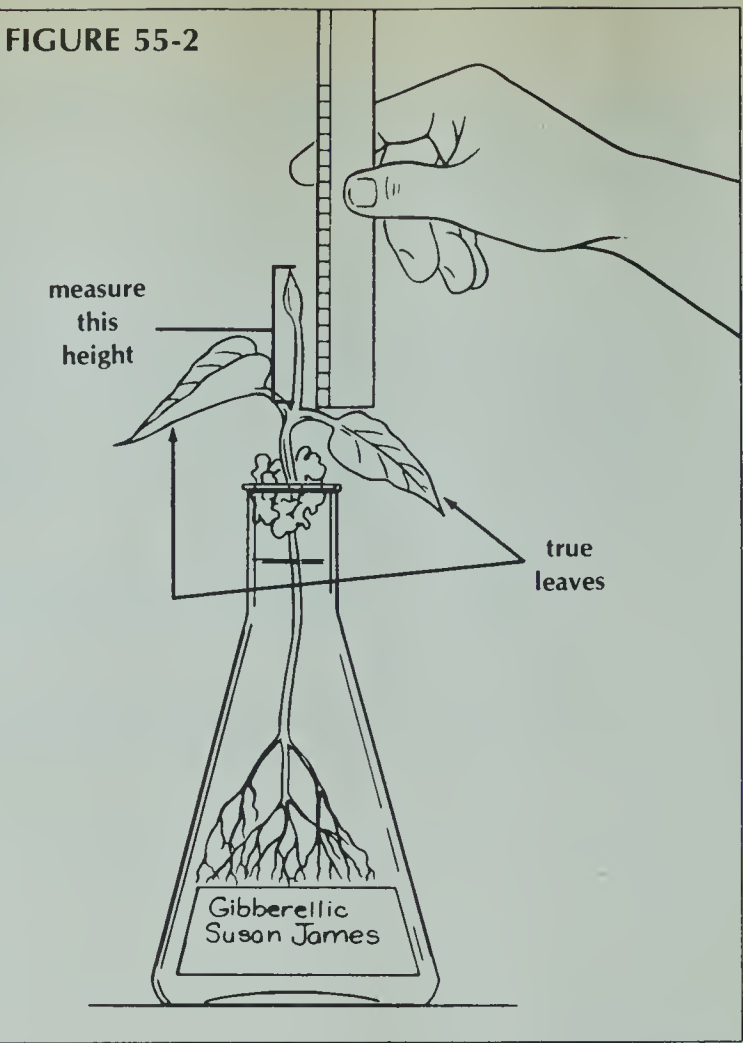


TABLE 55-1. GROWTH IN BEAN PLANTS (IN MILLIMETRES)					
DATE	DAY	PLANT IN WATER (CONTROL)		PLANT IN GIBBERELLIC ACID (EXPERIMENTAL)	
		HEIGHT	CHANGE IN HEIGHT	HEIGHT	CHANGE IN HEIGHT
	0				
	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
	10				

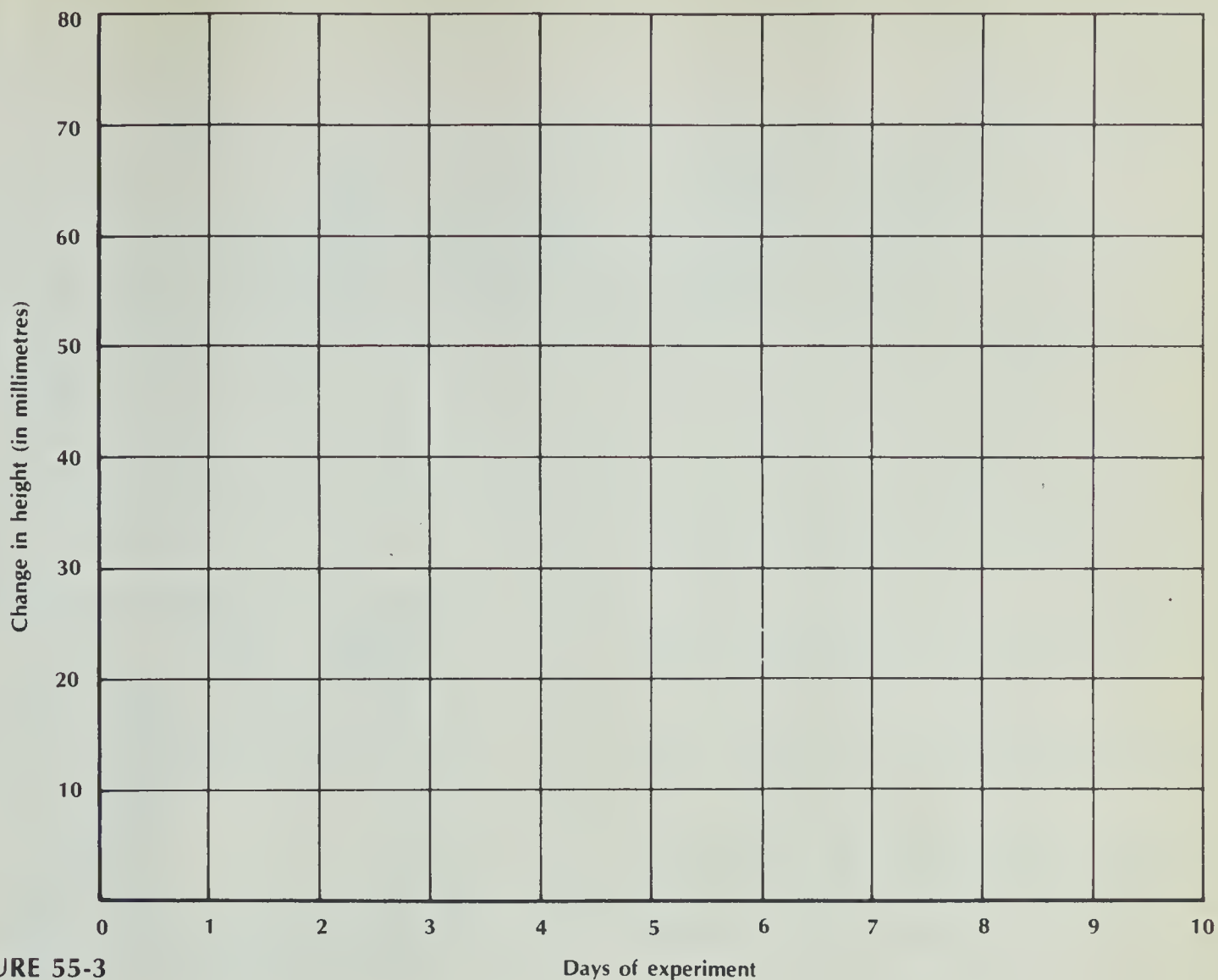


FIGURE 55-3

- On Figure 55-3 construct line graphs of your data. Plot the number of days since the start of the experiment along the horizontal axis and the change in height of the plants in millimetres along the vertical axis. There should be two lines on your graph—one for the plant in gibberellic acid and one for the plant in water. Label each line on the graph either "gibberellic acid" or "water."

Part B. Direction of Young Root and Stem Growth

- Cut a piece of corrugated cardboard that measures 26 cm \times 13 cm.
- Fold the cardboard in half so you have two 13 cm \times 13 cm sections. Use Figure 55-4A as a guide.
- Staple several thicknesses of paper toweling to the outside surface of one side of the cardboard. Use Figure 55-4B as a guide.
- With straight pins, attach four soaked corn seeds to the top of the paper toweling side of your cardboard. Position the seeds as in Figure 55-5.

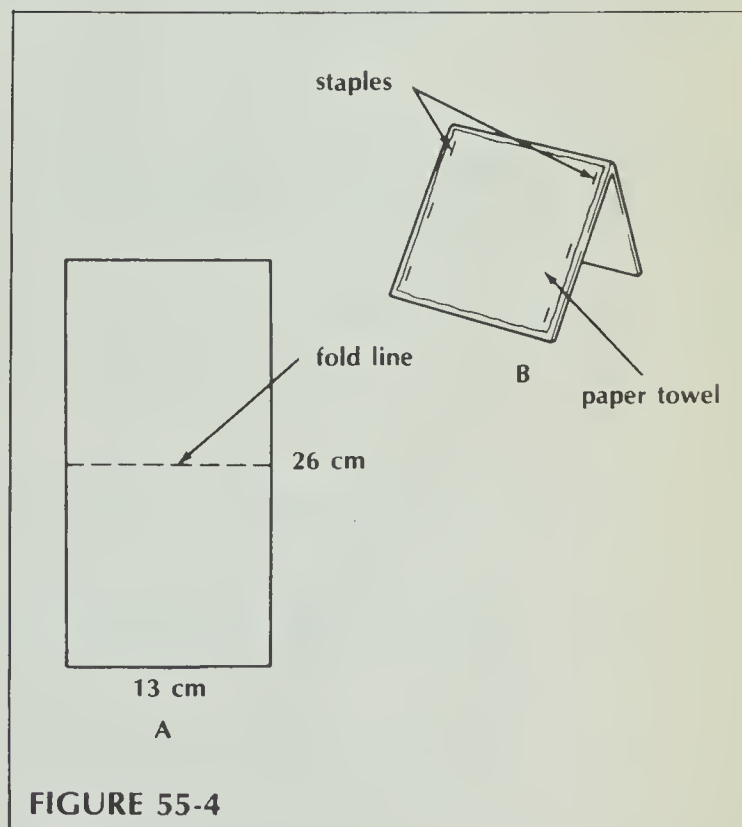


FIGURE 55-4

Note: It is important that pointed ends of the seeds face in the directions shown in the diagram.

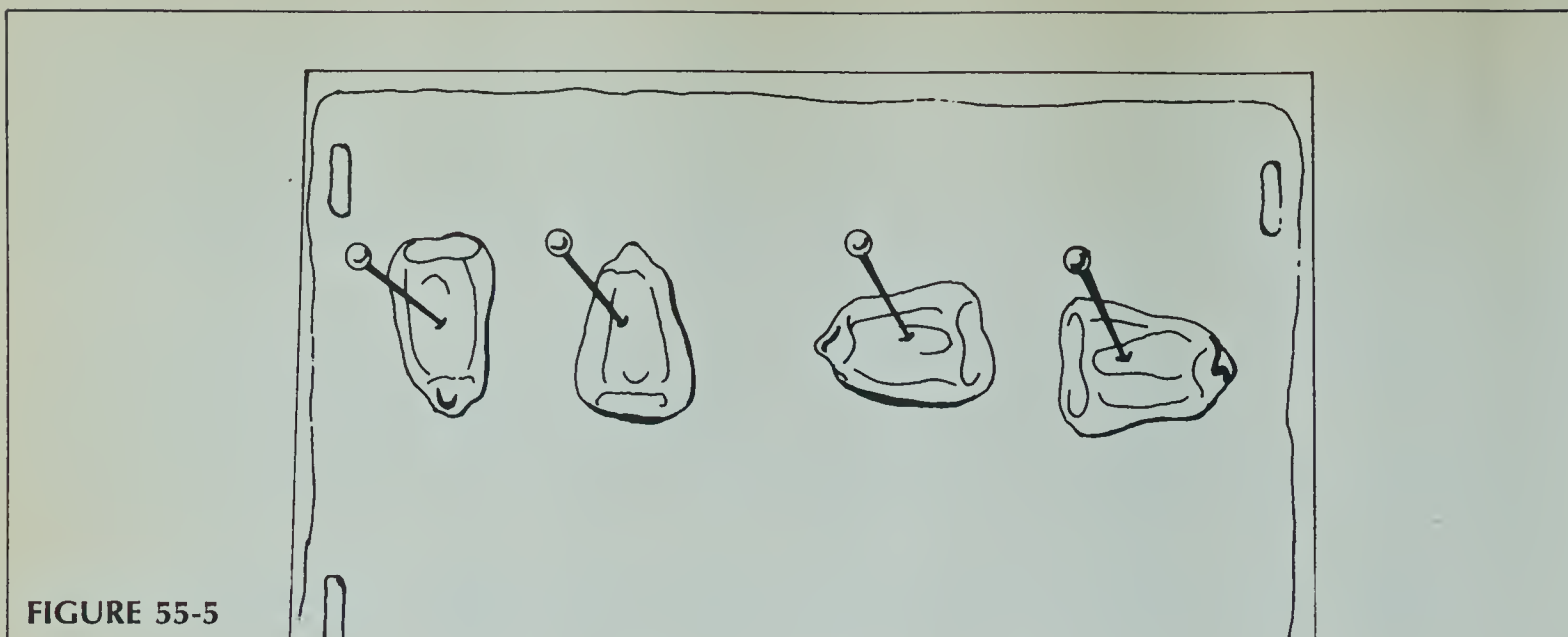


FIGURE 55-5

- Stand the cardboard into a shallow dish as shown in Figure 55-6.
- Pour in enough water to cover the bottom of the dish.
- Slip a plastic bag over the top to reduce drying out of the seeds.
- Add a label with your name and the date to the outside of the plastic bag.
- Place your seeds in an area designated by your teacher.
- Observe the seeds after 48 or 72 hours. Examine the seeds for the directions of root and stem growth.

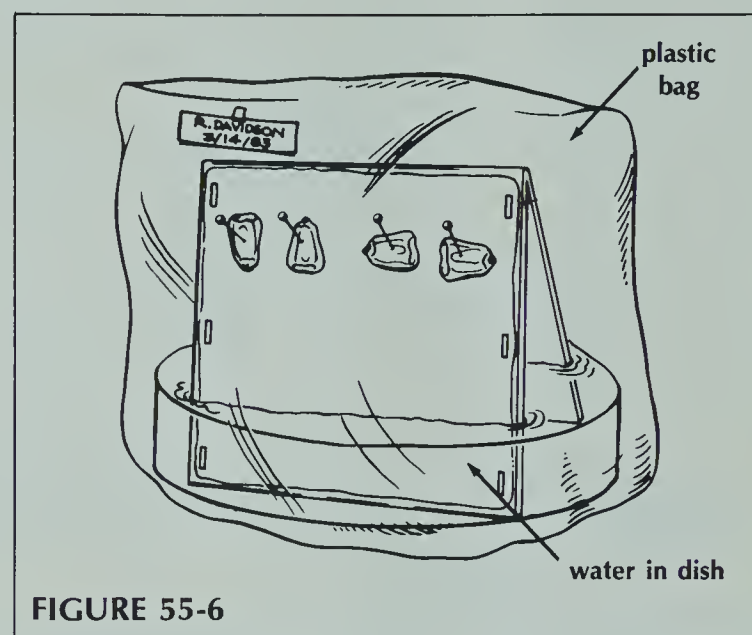


FIGURE 55-6

Roots originate from the pointed end of the seed. Stems originate from an area directly above where the root emerges. Stems may already appear green. Roots may already show some branching.

- Record the exact positions and directions of growth of new roots and stems for each seed by drawing these structures in Figure 55-7. Label the *root* and *stem* of each plant.

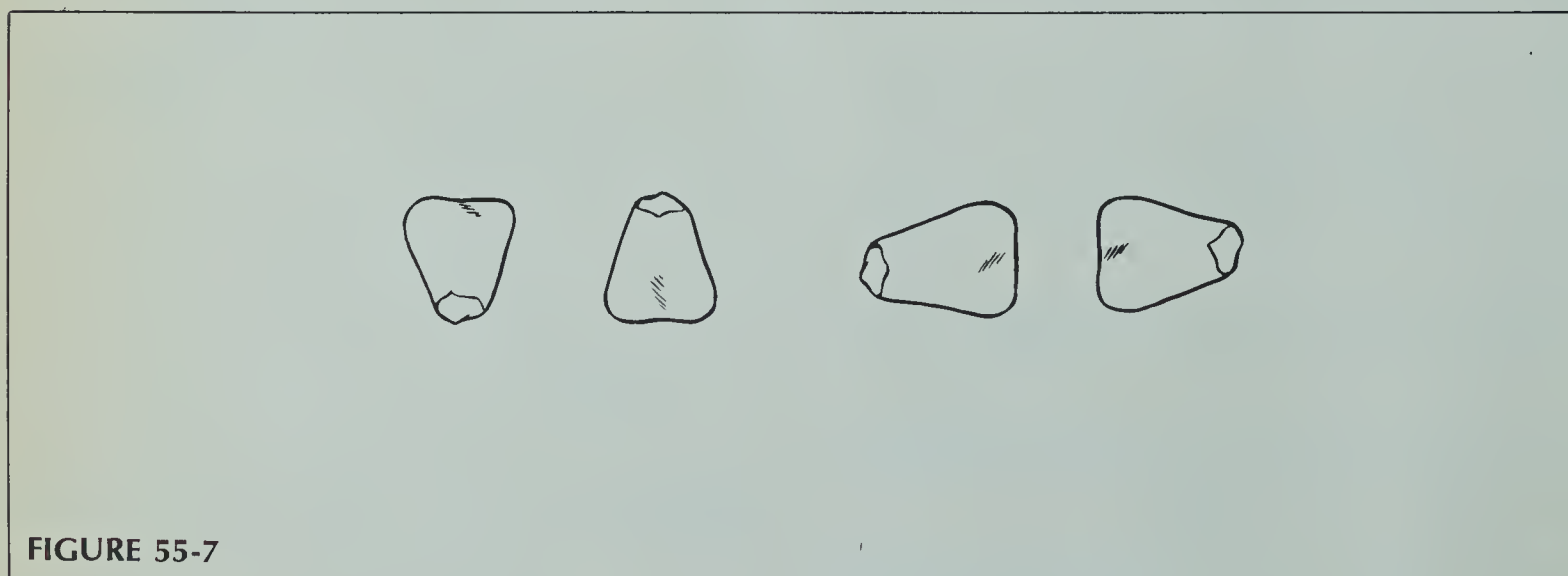


FIGURE 55-7

Analysis

1. Define hormone. _____

2. (a) What hormone was used in Part A of this experiment? _____
(b) What was the effect of this hormone on bean plant stem growth? (Use specific values from your data to support your answer.) _____

3. Why was a bean plant placed in water? _____

4. How do you know that hormones are needed in very small quantities to influence life processes? (Reread the materials list if you need help.) _____

5. In Part B, what is the direction of root growth from the seed with the pointed end facing
 - (a) down? _____
 - (b) up? _____
 - (c) parallel to the earth? _____
6. (a) What influence does the direction in which a seed is pointing have on the direction of root growth? _____
(b) In which direction (toward or away from the pull of gravity) do roots seem to grow? _____

7. What is the direction of stem growth from the seed with the pointed end facing
 - (a) down? _____
 - (b) up? _____
 - (c) parallel to the earth? _____

8. (a) What influence does the direction in which a seed is pointing have on the direction of stem growth?_____

(b) In which direction (toward or away from the pull of gravity) do stems grow?_____

The growth of roots and stems either toward or away from gravity is due to auxins (plant chemical hormones). These chemicals are present in young, newly forming roots and are distributed unevenly within root cells. Gravity pulls these auxins toward the bottom of root cells. The upper portion of root cells has less auxin than the lower portion. The bottom surface of root cells responds to the increase in auxin by growing slower while the top surface of these same cells grows faster due to the lower concentration of auxin. Cells along the top of the root grow faster than those along the bottom. This unequal growth causes the new young root to curve down toward gravity.

Young stem cells respond to these auxin amounts in a way directly opposite to that of roots. Stem cells also have more auxin along the bottom surface due to gravity and less auxin along the top surface. Their top surface grows slower while the bottom surface grows faster. As a result, stem tissue turns upward away from gravity.

9. Explain how the growth of a young root cell is influenced by

(a) little auxin._____

(b) much auxin._____

10. Explain how the growth of a young stem cell is influenced by

(a) little auxin._____

(b) much auxin._____

11. (a) Are root and stem cells responding in a similar or different manner to auxins present?

(b) Explain._____

12. (a) When you garden, must you always be careful about the direction a seed faces when planted in the ground?_____

(b) Explain._____

REGENERATION—A FORM OF ASEXUAL REPRODUCTION

56

Some plants and animals produce sex cells which function in sexual reproduction. Some living organisms also are capable of asexual reproduction. Almost any cell of the organism can divide asexually and produce new body cells by mitosis without first forming sex cells. One type of asexual reproduction is regeneration. In regeneration, a plant or animal regrows missing or lost parts.

In this investigation, you will

- observe with a microscope the normal appearance and reactions of a planarian.
- locate the eyespots, auricles, and pharynx of a planarian.
- cut a planarian in half forming front (anterior) and back (posterior) sections, and observe these two parts daily.
- record daily changes in appearance by making accurate drawings.

Materials

planarian
razor blade (single-edge)
petri dish (or plastic margarine dish)
modeling plastic or clay (optional)
pond water

glass marking pencil (or masking tape and pen)
cotton swab
microscope
microscope slide

Procedure

- Divide a petri dish in half by building a ridge on the inside with clay. Make a ridge 1 cm high. If clay is not available, use two dishes.
- Fill each section of dish with pond water. Make sure that water does not flow over the clay barrier in a divided dish (Figure 56-1).
- Place a planarian and a small amount of pond water onto a microscope slide.
- Observe the planarian with low power magnification of your microscope. Observe the following using Figure 56-2 as a guide.
 - distinct head region consisting of eyespots and earlike structures called auricles
 - pharynx, tubelike structure on the underside of the animal
 - tail region

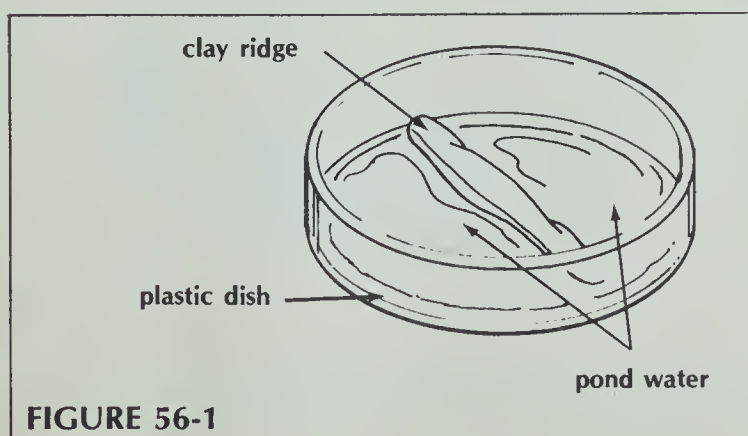


FIGURE 56-1

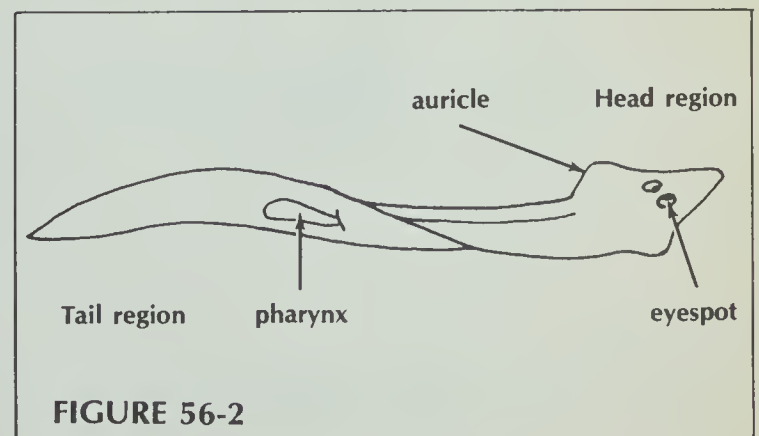
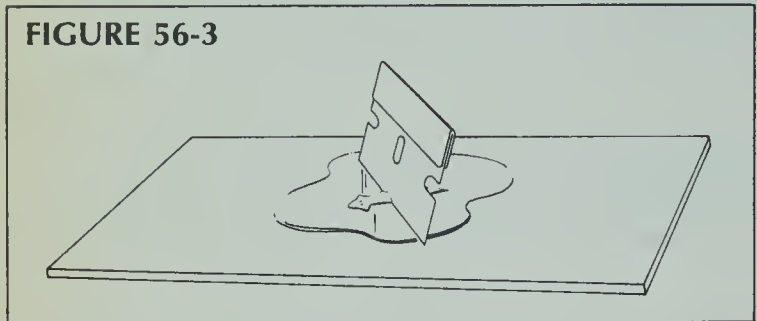


FIGURE 56-2

Planarians are sensitive to light and will move away while being viewed under the microscope. Which end of the animal leads as it moves away

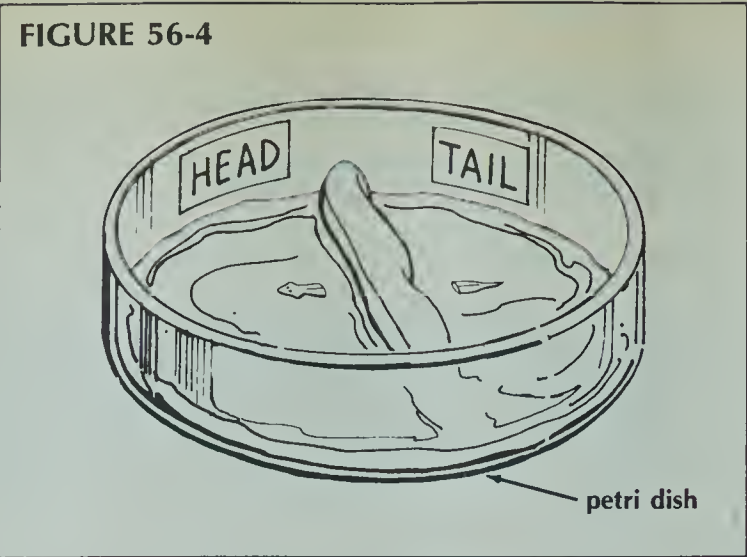
from the light?_____

● Remove the slide from the microscope. Wait for the animal to stretch out. Then, cut it into front and rear halves with a sharp, clean razor blade (Figure 56-3). **CAUTION:** *Blade is sharp. Cut away from fingers.*



- With a cotton swab, transfer the planarian halves to your dish, or dishes. Put each half into a separate section or dish. Label the section or dish with a marking pencil or masking tape and pen. Identify each section or dish with the planarian half it contains as shown in Figure 56-4. Also add your name and the date.
- Store the dish or dishes in a cool dark area of the room.
- Observe the planarian halves every day. Add pond water as needed to keep the animal from

FIGURE 56-4



drying out. With a cotton swab, transfer each half to a microscope slide for microscopic examination. Observe the halves until each has regenerated completely. Record observations in Table 56-1.

- Make diagrams of each half as it appears during each examination. Include the following in your diagrams:
 - (a) appearance and extent of clear areas around the cut region
 - (b) appearance and extent of pigmented areas around the cut region
 - (c) number of days since start of investigation
 - (d) appearance of new eyespots and auricles in the posterior half

TABLE 56-1. DATA CHART				
DATE	DAY	DIAGRAMS		COMMENTS
		HEAD	TAIL	

Analysis

Write a report which describes the changes in each half as it regenerates. Also, include how many days each half takes to regenerate. Include any diagrams which support your observations and conclusions.

THE MENSTRUAL CYCLE

57

A number of stages or phases occur as the human female reproductive system prepares for egg fertilization. These stages are all under hormonal control. The entire cycle of stages usually takes about 28 days. However, as the last phase finishes, the first stage begins again. This process results in a cyclic pattern which repeats every 28 days. The cycle is called the menstrual cycle and occurs in human females once they reach puberty or sexual maturity. To aid in the study of this cycle, the menstrual cycle will be divided into 3 separate stages.

In this investigation you will

- study and graph changes occurring during the follicle stage of the menstrual cycle.
- study and graph changes occurring during the luteal (corpus luteum) stage of the menstrual cycle.
- study and graph changes occurring to the uterus during both the follicle and luteal stages of the menstrual cycle.

Materials

colored pencils

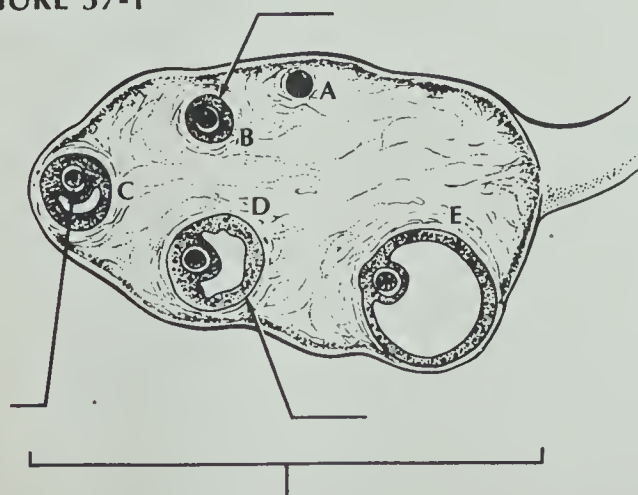
Procedure

Part A. Follicle Stage

Within the ovaries are located many egg cells. Each egg is enclosed within a structure called a follicle. The follicle is said to be immature. Under the influence of a hormone called FSH (follicle-stimulating hormone), the follicle matures.

Figure 57-1 shows the various stages of one follicle's maturation. An immature follicle is small in comparison to a mature follicle. The egg is shown within the follicle. The entire structure containing the follicles is an ovary. Keep in mind that one ovary contains many immature follicles.

FIGURE 57-1



- Label these structures on Figure 57-1: *egg*, *immature follicle*, *mature follicle*, *ovary*.

What directs a follicle to mature? A hormone called follicle stimulating hormone (FSH) is responsible. The amount of FSH in the blood-stream influences the changes just described. Table 57-1 shows data obtained from blood samples taken from a female and analyzed for the amount of FSH present in her body.

- Prepare a line graph of the data in Table 57-1. Use the graph marked Figure 57-2.

- Across the top of Figure 57-2, draw in the various stages of follicle maturation occurring at each letter. The drawings should match the letter stages

TABLE 57-1. AMOUNT OF FSH PRESENT

DAY	UNITS OF FSH	DAY	UNITS OF FSH
1	10	15	10
3	12	17	9
5	14	19	9
7	13	21	8
9	13	23	8
11	14	25	8
13	20	27	10

in Figure 57-1. Note the arrow across the top of the graph. This arrow shows that the events happen in a continuous cycle.

- Starting with day 24 and going to day 13, how does the amount of FSH in the body appear to change? _____
- Starting with day 24 and going to day 13, what happens to the follicle? _____
- (a) What hormone is responsible for the changes in the follicle? _____
(b) Why is this hormone correctly named? _____
- During which days of the cycle is there the least amount of this hormone in the bloodstream? _____
- What is happening to the next follicle at this time? _____
- Events described so far are called the follicle phase. From start to finish, how many days in total does this phase take? _____

FSH is produced by a small gland at the base of the brain called the pituitary gland.

- Complete Figure 57-3 showing the relationship between the pituitary gland and ovary. Label the following parts: *FSH*, *ovary*, *pituitary gland*.

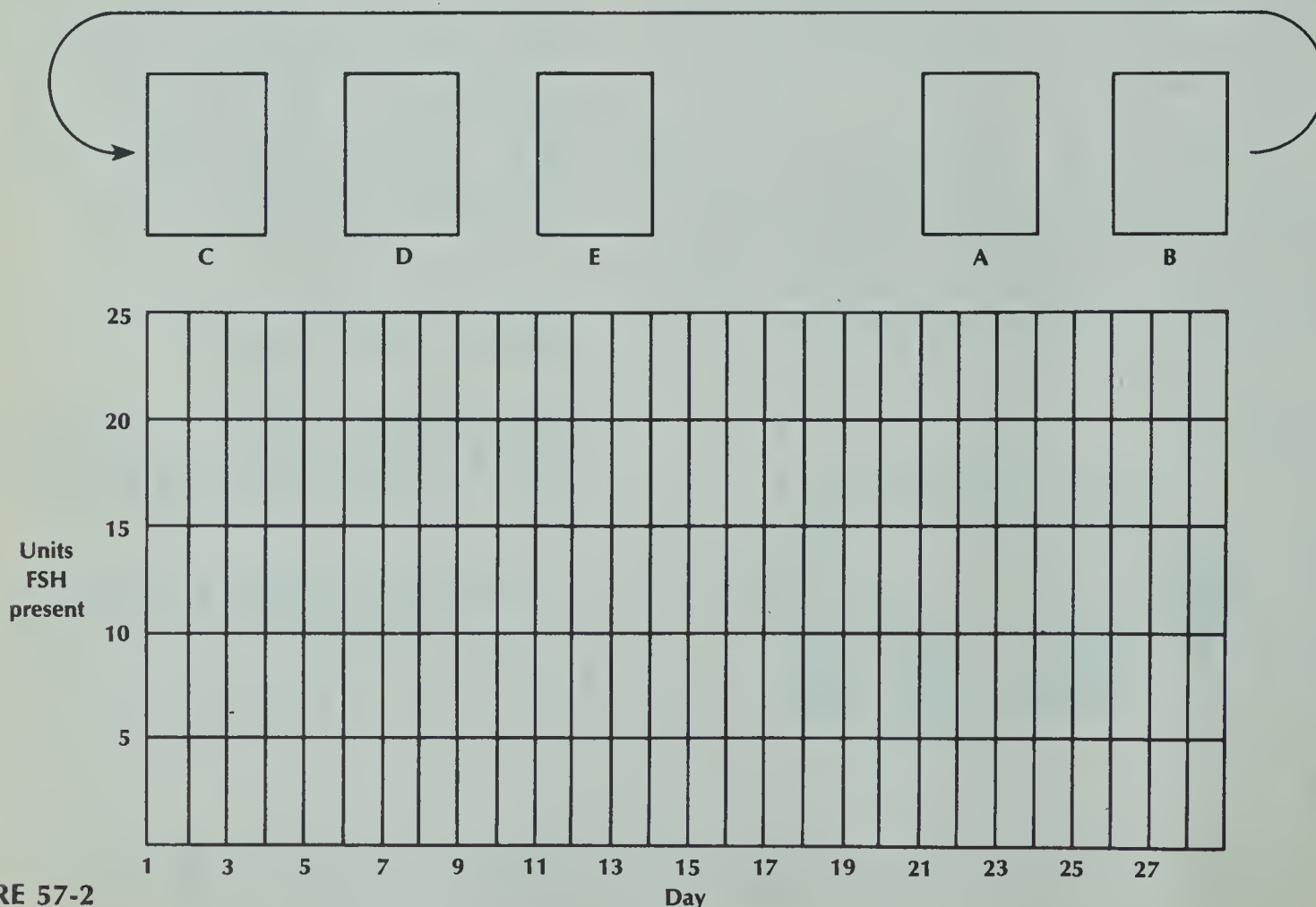
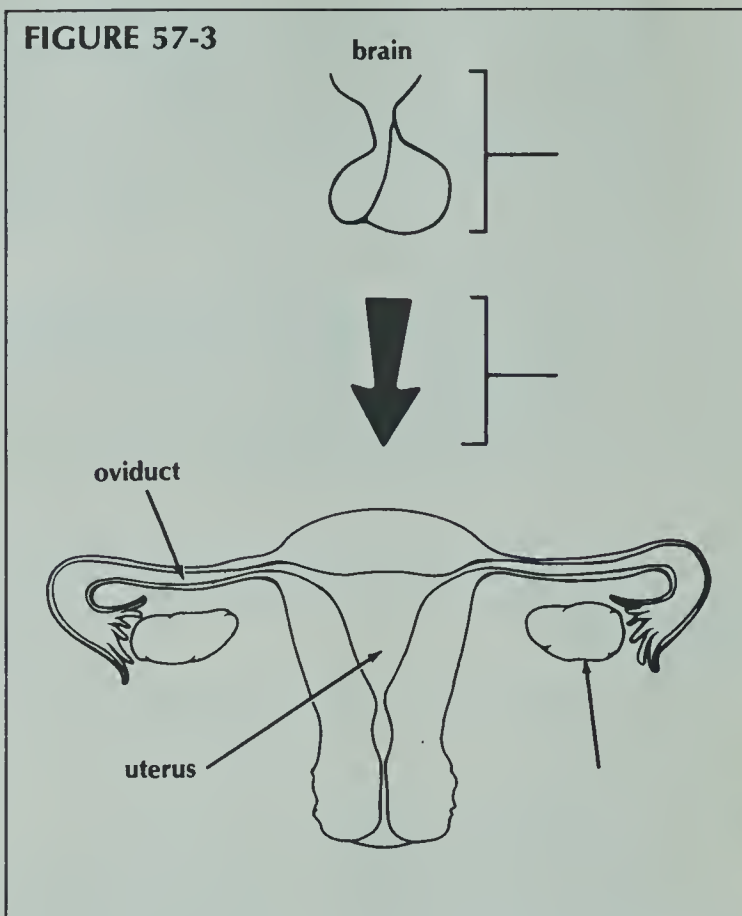
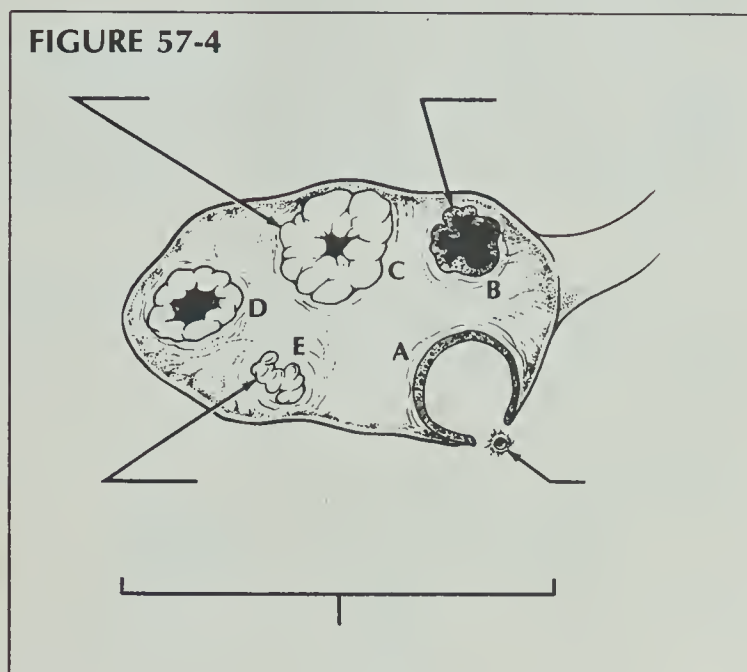


FIGURE 57-2

Part B. Luteal Stage

Once a follicle is mature, it bursts open and the egg is released. The egg passes into the oviduct where it may or may not become fertilized. Meanwhile, the mature follicle, once it loses its egg, forms a body within the ovary called the corpus luteum.

Figure 57-4 shows the changes of the corpus luteum. A mature corpus luteum is rather large. After maturation, the corpus luteum begins to break apart and disappear.



- Label these structures in Figure 57-4: *newly formed corpus luteum, mature corpus luteum, disappearing corpus luteum, ovary, egg release.*

A hormone called luteinizing hormone (LH) is responsible for the changes in the corpus luteum. The amount of this hormone in the bloodstream influences the changes just described. LH is also produced by the pituitary gland.

Table 57-2 shows data obtained from blood samples taken from a female and analyzed for the amount of LH present.

- Prepare a line graph of the data from Table 57-2. Use the graph marked 57-5.

- Across the top of Figure 57-5, draw in the various stages of corpus luteum formation. The drawings should match the lettered stages in Figure 57-4.

TABLE 57-2. AMOUNT OF LH PRESENT			
DAY	UNITS OF LH	DAY	UNITS OF LH
1	12	15	12
3	14	17	12
5	14	19	12
7	14	21	12
9	14	23	12
11	16	25	8
13	70	27	8

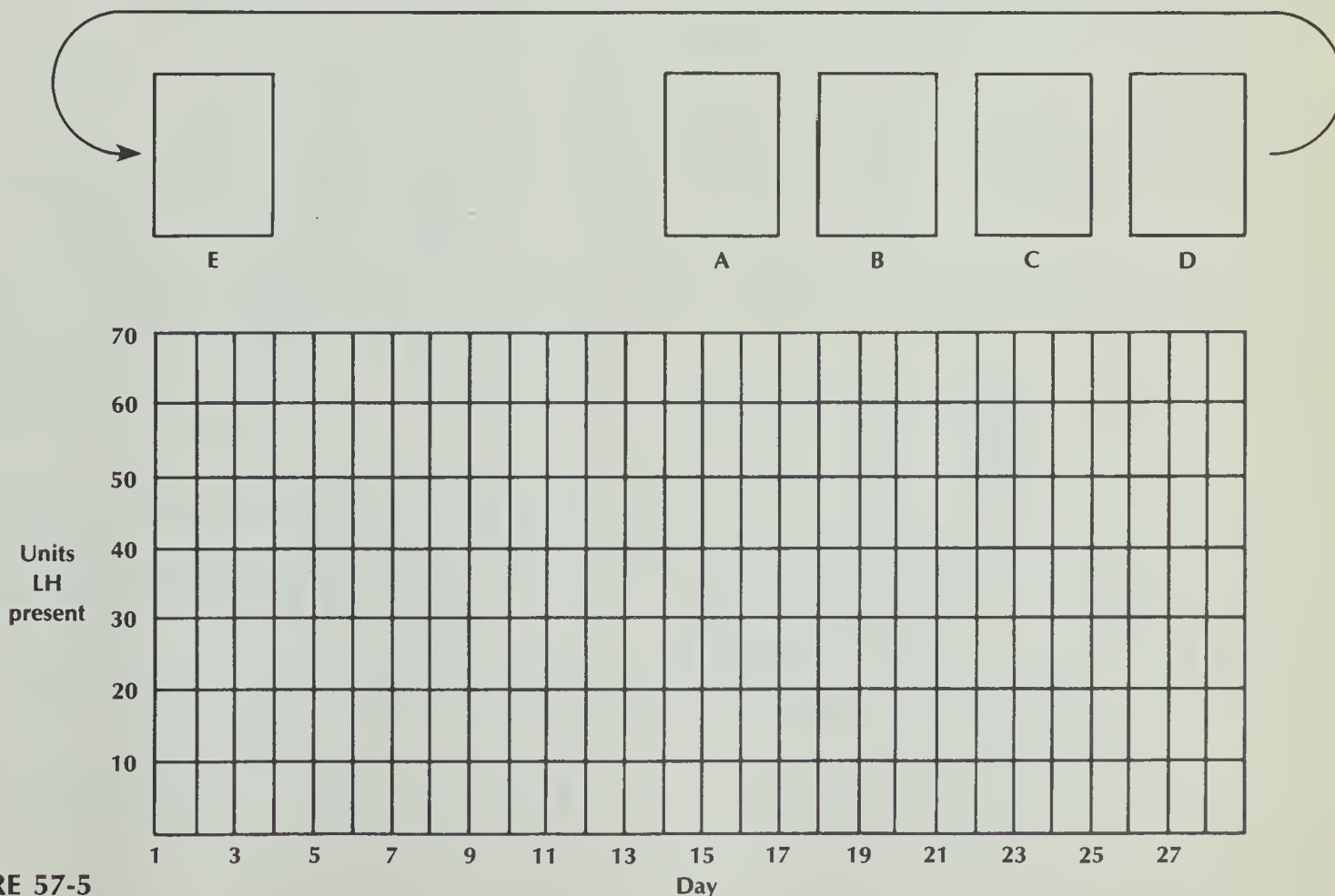
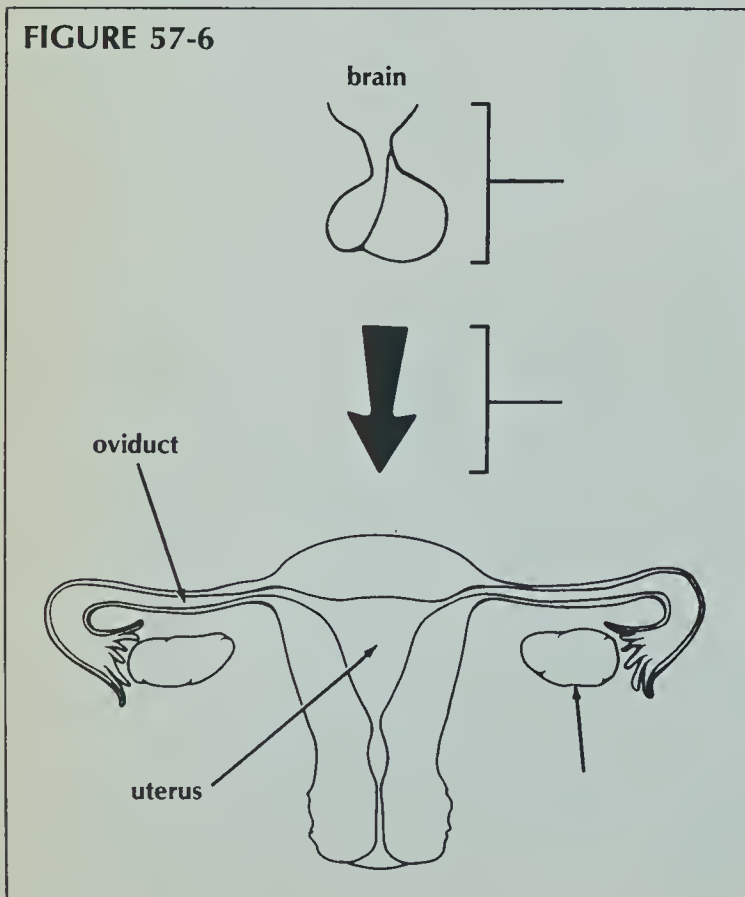


FIGURE 57-5

7. On what day does LH suddenly increase to its maximum amount?_____
8. What event occurs the next day?_____
9. (a) On day 15 through 23, how does the amount of LH change?_____
- (b) What is happening to the corpus luteum during this time?_____
10. (a) During which days is LH at its lowest amount in the body?_____
- (b) What happens to the corpus luteum at this time?_____
11. (a) What is the full name of LH?_____
- (b) Why is LH correctly named?_____
12. Events described in this section are called the luteal stage. From start to finish, how many days in total does the luteal stage last?_____

• Complete Figure 57-6, labeling the following parts: *LH*, *ovary*, *pituitary gland*.



Part C. Changes in the Uterus

While the follicle and luteal stages are taking place in the ovaries, a series of changes is also occurring in the uterus. The uterus lining changes from being very thin to being very thick. This change in thickness occurs because the number of cells increases through rapid cell division. At one point the uterus ceases to thicken. The buildup of cells begins to break apart. This loss of uterine lining is called menstruation. It is accompanied by tissue loss as well as bleeding.

• Figure 57-7 shows several stages of uterus lining buildup. Label these structures: *thin uterus lining*, *menstruation*, *thick uterus lining*.

Two hormones are responsible for the thickening of the uterus. They are called estrogen and progesterone. The amount of these hormones in the bloodstream influences the changes just described.

Table 57-3 shows data obtained from blood samples taken from a female and analyzed for the amount of these hormones present.

FIGURE 57-7



TABLE 57-3. AMOUNT OF ESTROGEN AND
PROGESTERONE PRESENT

DAY	UNITS OF ESTROGEN	UNITS OF PROGESTERONE	DAY	UNITS OF ESTROGEN	UNITS OF PROGESTERONE
1	50	5	15	75	40
3	50	5	17	100	60
5	50	5	19	100	110
7	75	5	21	100	150
9	125	5	23	100	150
11	225	5	25	50	100
13	200	10	27	50	30

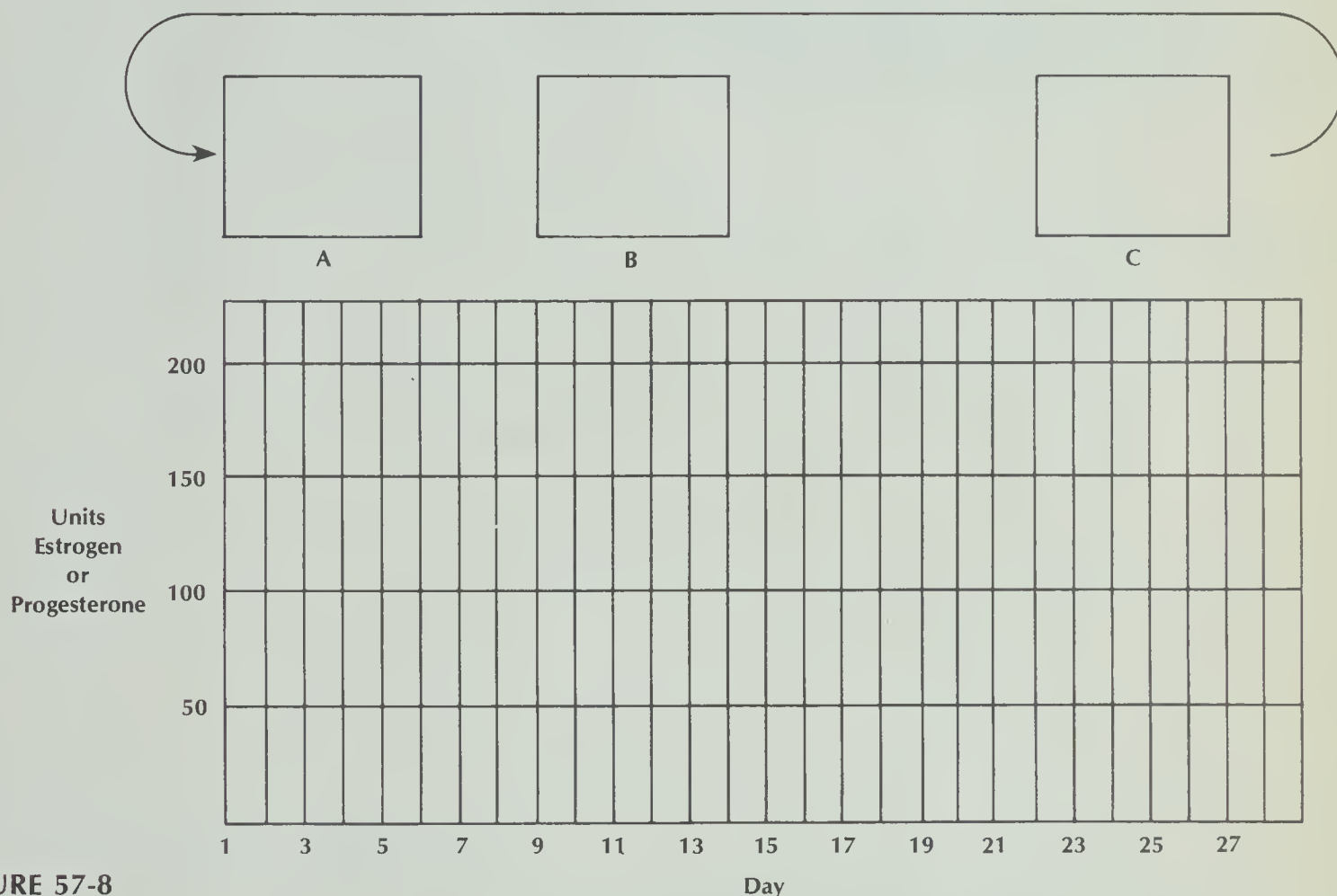


FIGURE 57-8

• Prepare a line graph of the data from Table 57-3. Use the graph marked Figure 57-8. Use a different colored line for each hormone and indicate on your graph which line represents which hormone.

• Across the top of Figure 57-8, draw the various stages of uterus thickness occurring at each letter. The drawings should match the lettered stages on Figure 57-7.

13. (a) Starting with day 5 and going to day 11, how does the amount of estrogen in the body change? _____
 (b) What is occurring to the uterus during this time? _____

14. (a) Starting with day 13 and going to day 24, how does the amount of progesterone in the body change? _____
 (b) What is happening to the uterus during this time? _____
15. Does it appear as if estrogen and progesterone are both bringing about similar changes in the uterus? _____
16. (a) During which days are the levels of progesterone and estrogen both at their lowest? _____
 (b) What happens to the uterus at this time? _____

17. Do the days when a follicle is maturing (Figure 57-2) seem to best match when estrogen

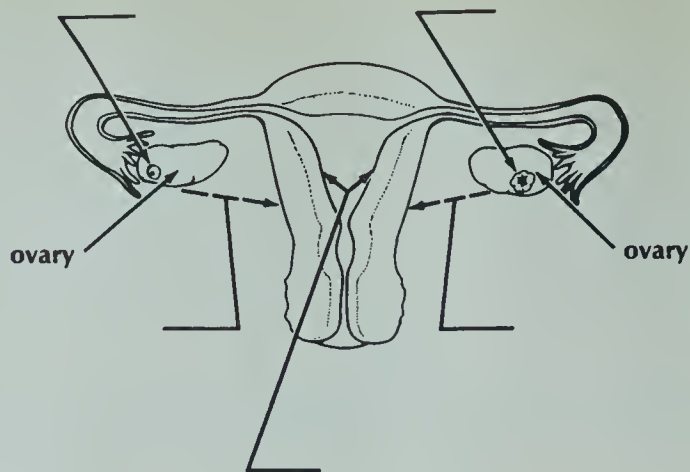
or progesterone is increasing?_____

18. Do the days when a corpus luteum is maturing (Figure 57-5) seem to best match the days when estrogen is increasing or when progesterone is increasing?_____

Estrogen is produced by the maturing follicle. Progesterone is produced by the corpus luteum.

• Complete Figure 57-9 showing the relationship among these reproductive structures. Label the following parts: *corpus luteum*, *estrogen*, *progesterone*, *maturing follicle*, *thickening uterus*.

FIGURE 57-9



Analysis

1. Name the two hormones produced by the pituitary gland._____

2. (a) Name the two hormones produced by structures within the ovary._____

(b) What structures within the ovary are responsible for production of each hormone?

3. (a) Follicle maturation is controlled by what hormone?_____

(b) Egg release is controlled by what hormone?_____

(c) Corpus luteum development is controlled by what hormone?_____

4. (a) Summarize the events occurring during the follicle stage._____

(b) Summarize the events occurring during the luteal stage._____

5. (a) Which two hormones control the thickening of the uterus?_____

(b) Using Figure 57-8, which hormone is formed first in this phase of the cycle?_____

(c) Using Figure 57-8, which hormone is formed last in this phase of the cycle?_____

(d) Does one hormone tend to drop in amount while the other is increasing?_____

On what days does this overlapping seem to occur?_____

6. Explain why the events described in this investigation are referred to as a cycle._____

CHICK DEVELOPMENT

58

When an egg cell is fertilized by a sperm cell, it begins to undergo many changes. These changes include a series of rapid cell divisions. Thus, the fertilized egg quickly becomes a many celled embryo. Once this many celled stage is reached, organs begin to form. The orderly formation of tissues, organs and systems in an embryo is called development.

In order for a chick egg to develop, two requirements must be met. First, the egg must be fertilized by sperm from a male chicken. Second, the eggs must be kept warm by the female chicken or placed in an incubator for 21 days. Eggs purchased in the grocery store usually are not fertilized and have not been incubated.

In this investigation, you will

- (a) examine a chicken egg to identify its parts.
- (b) compare diagrams of a 24, 48 and 72 hour old developing chicken embryo.
- (c) determine the sequence in which the chicken embryo's organs appear during development.

Materials

chicken egg
tweezers
water
small dish or bowl

Procedure

Part A. Examining a Chicken Egg

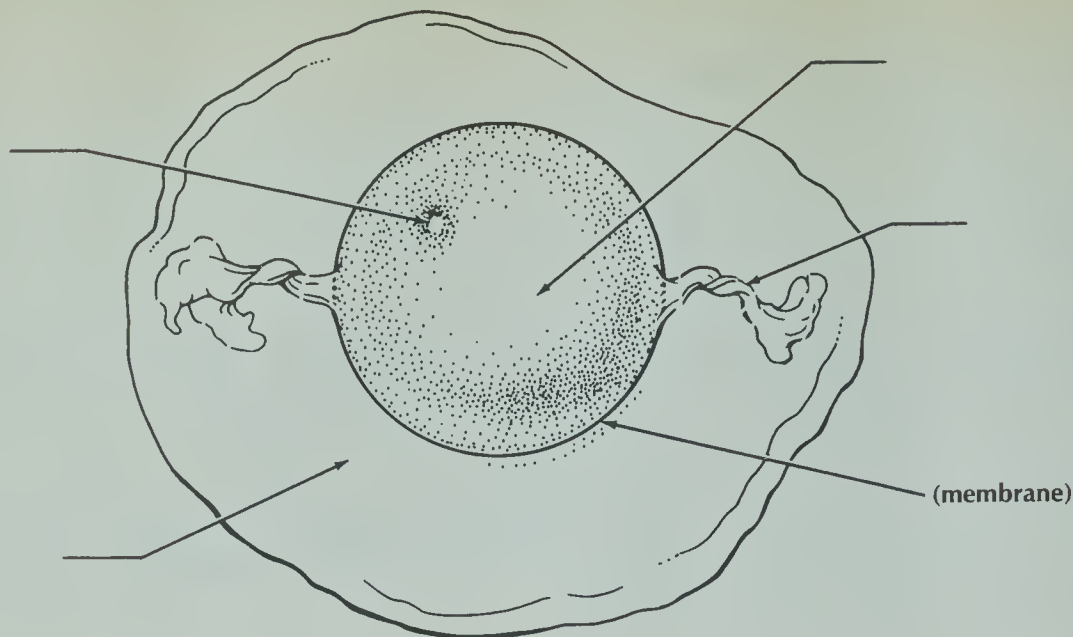
- Examine a chicken egg by following these 3 steps:

- *Step 1.* Fill a small bowl with water.
- *Step 2.* Gently crack the eggshell along its center on the bowl edge.
- *Step 3.* Place the cracked egg into the bowl and gently open the shell. NOTE: Save the shell.
- The following parts should be noted:
 - (a) *yolk*—round, yellow/orange. Consists of protein and fat.
 - (b) *albumen*—clear liquid, surrounding yolk; made of protein.
 - (c) *chalaza*—two cordlike parts of thickened albumen at either end of yolk.
 - (d) *blastodisc*—small, almost dotlike white disk on top of yolk. NOTE: You may have to turn the yolk gently in order to see the blastodisc.

The blastodisc contains a single structure, the egg cell. All other parts such as yolk and albumen are stored food to be used during development of the chick.

- Touch the yolk gently with a pencil. Note that it is enclosed by a membrane called the vitelline membrane.
- Label the following structures on Figure 58-1: *yolk, vitelline membrane, chalaza, blastodisc, albumen.*
- Examine the ends of the eggshell. One end is more rounded than the other.
- Using the more rounded end, note the thin membrane on the inside of the shell. Use the tweezers to break this membrane.

FIGURE 58-1



1. What is found directly below this membrane?

• Use the tweezers to pull the broken membrane away from the shell.

2. Does the membrane continue along the inside of the shell? _____

Part B. Changes During Development

If a fertilized egg is kept warm (about 38°C) for 21 days, it will develop from a single cell to a baby chick. Various organs will form in a specific order during development.

• Figures 58-2, 3, and 4 show the appearance of a chicken at various times during development.

• Label the parts shown on Figures 58-2, 3, and 4. Each part is numbered and matches the numbered part listed in Figure 58-3. A part called a somite has been labeled for you in each figure. This structure forms skin, muscle and bone and will not be included in our study.

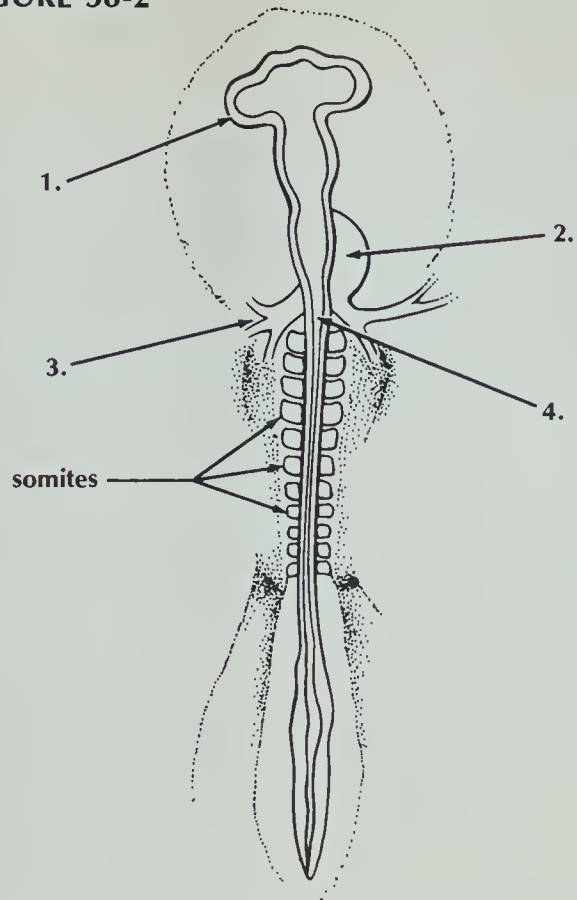
Part C. Order of Developing Systems

The developing organs shown in Part B are listed in Table 58-1 by number. Each numbered part has been grouped into the proper animal system to which it belongs.

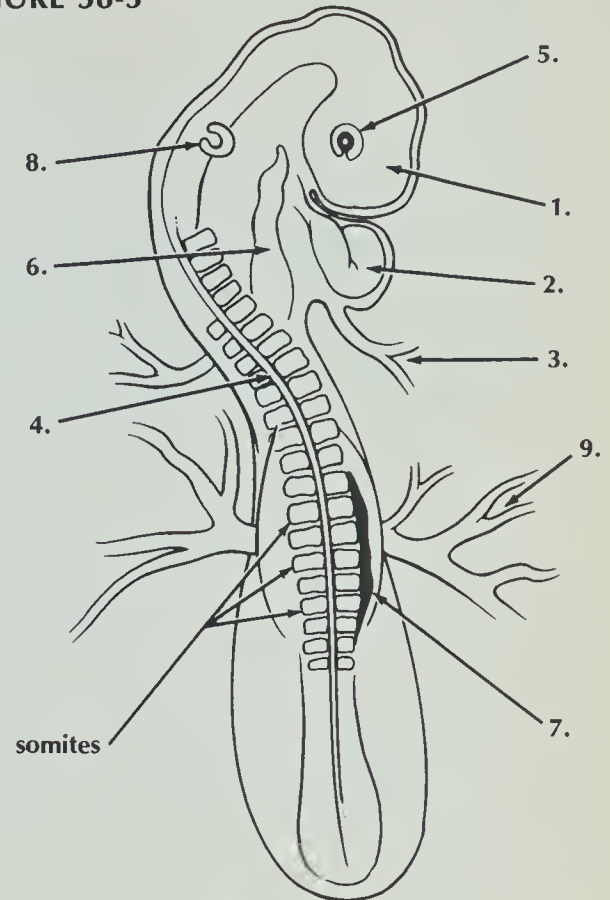
• Complete Table 58-1 by placing organ numbers in the proper time column to indicate when the organs listed appeared. (It may be necessary for you to recheck the organs labeled in Figures 58-2, 3, and 4).

TABLE 58-1. SYSTEMS OF A DEVELOPING CHICKEN

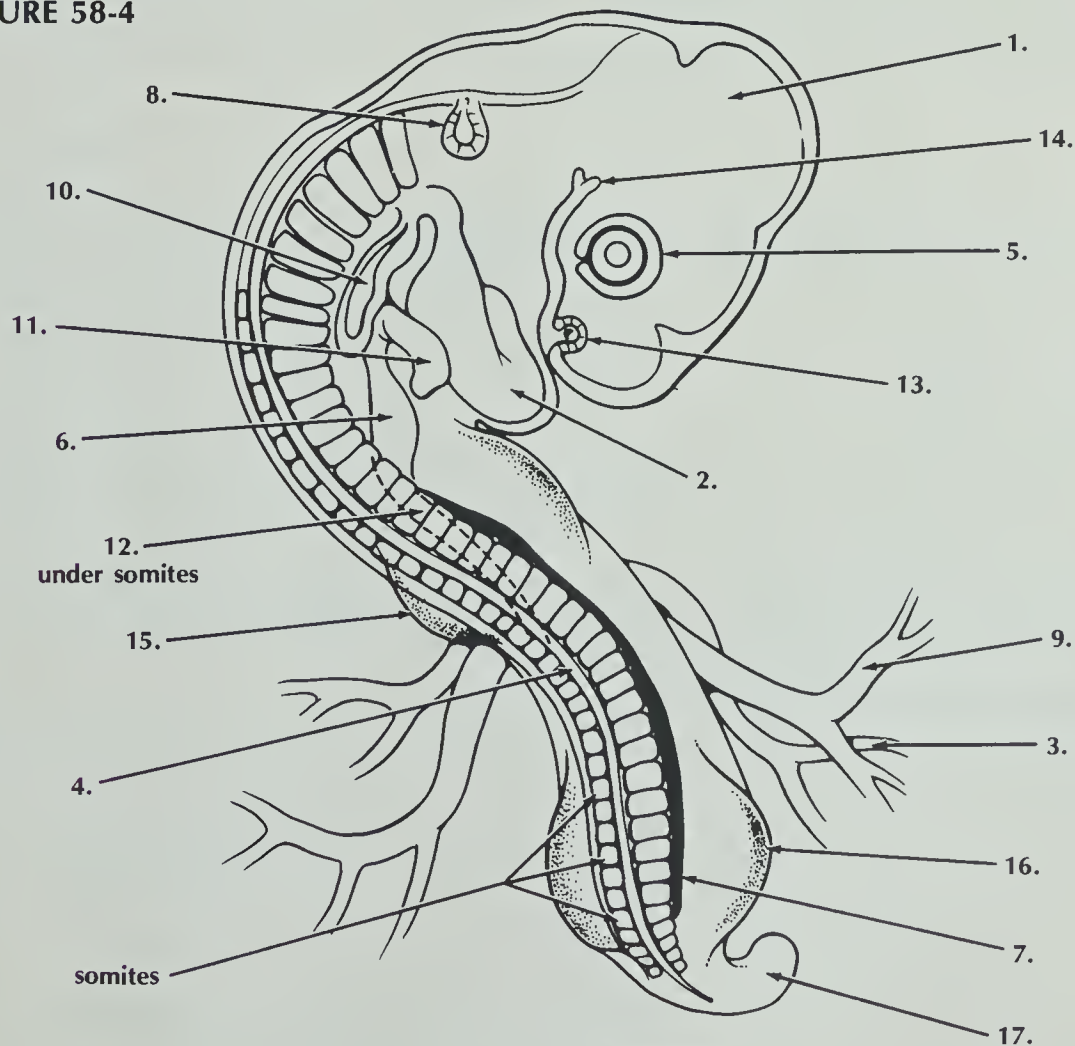
SYSTEM	ORGANS IN EACH SYSTEM	PRESENT AS OF		
		24 HOURS	48 HOURS	72 HOURS
Circulatory	2, 3, 9			
Digestive	6, 11, 12, 14			
Excretory	7			
Muscular/Skeleton	15, 16, 17			
Nervous	1, 4, 5, 8, 13			
Respiratory	10			

FIGURE 58-2

24 Hours Into Development

FIGURE 58-3

48 Hours Into Development

FIGURE 58-4

72 Hours Into Development

1. brain
2. heart
3. veins
4. spinal cord
5. eye
6. stomach
7. kidney
8. ear
9. arteries
10. lung
11. liver
12. intestine
13. nose
14. mouth
15. wings
16. hind legs
17. tail

Analysis

1. Define development. _____

2. Unlike mammals, a developing bird receives no food or oxygen from its mother.
 - (a) What supplies the developing chick with food? _____
 - (b) Where does a developing chick get its oxygen supply? _____
 - (c) Through what structure (or structures) must oxygen pass through on its way to the chick? _____

3. What is the most obvious function of the shell? _____

4. If one could examine a 12 hour old chicken embryo, one would note that only the nervous system had formed. With this information, list in correct order the first two systems to form during development of a chicken. _____

5. Chicks increase in size during development as new cells are supplied with food nutrients. Food is supplied by the developing chick through the egg yolk. What role do the arteries, veins, and heart (which all form at an early age) play in food distribution? _____

6. What changes (new organs) occur in the nervous system between
 - (a) 24 and 48 hours? _____

 - (b) 48 and 72 hours? _____

7. What changes (new organs) occur in the digestive system between
 - (a) 24 and 48 hours? _____

 - (b) 48 and 72 hours? _____

FRUIT FLY DEVELOPMENT

59

Development can be defined as a series of changes in shape or form that living things undergo in reaching their adult or final form. These changes during an animal's life cycle often result in a series of stages that are unlike the final or adult form in many ways. For example, a tadpole is a stage in the development of a frog, yet it does not greatly resemble the adult. A caterpillar is a stage in the development of a moth or butterfly that shows little resemblance to the adult form. Other insects also show a variety of stages during their development. The common fruit fly will be used in this activity because its stages are easily recognized.

In this investigation, you will

- identify the four stages appearing during fruit fly development.
- examine certain fruit fly life stages under a dissecting microscope or hand lens.
- compare similarities and differences between stages.

Materials

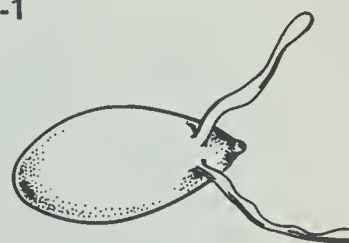
dissecting microscope or hand lens
wood splint
tweezers
glass slide

shallow dish or watchglass
container of fruit flies showing all stages of development
container of fruit flies with no adults

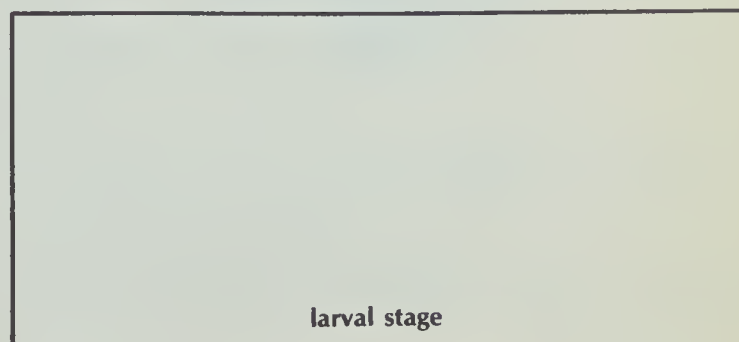
Procedure

- Examine a container of fruit flies containing adults. Identify the following stages:
 - adult fruit fly*—appears much like a common housefly only smaller, has all body parts usually seen in adult insects, capable of flying, found above food layer.
 - larva*—appears as a tiny wormlike animal, white, moves slowly and often can be found making tunnels within the food layer.
 - pupa*—appears as a very light brown wormlike animal, found clinging to the walls of the upper part of the container, does not move.
- Secure a container of fruit fly life stages without adults for closer examination.
- Use a splint to remove some of the food at the bottom of the container.
- Place the food into a shallow dish or watchglass.
- Pick through the food with tweezers looking for eggs as well as larva stages. Eggs will appear as very small oblong bodies resembling Figure 59-1.

FIGURE 59-1

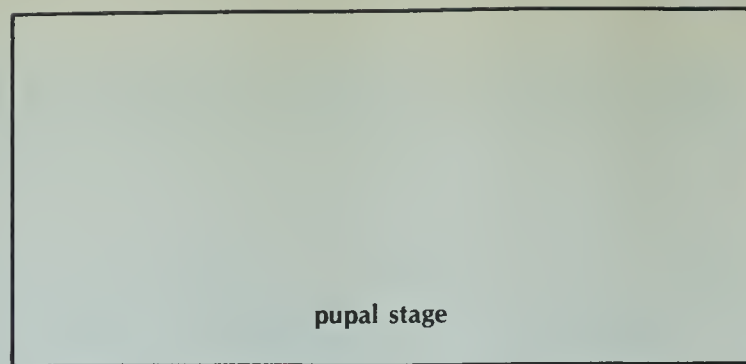


- Place the dish onto a dissecting microscope stage (or use a hand lens) to observe the eggs and larvae.
- Diagram a larva in the space provided.



larval stage

1. Describe the body shape of the larvae. Indicate if they are in segments. _____



● Use tweezers to pick off one or two pupae. Place them on a glass slide and examine them under a dissecting microscope or hand lens. Look for adult insect parts that may be recognizable in a pupa. Diagram a pupa in the space provided.

2. What adult body parts can be seen forming within the pupa? _____

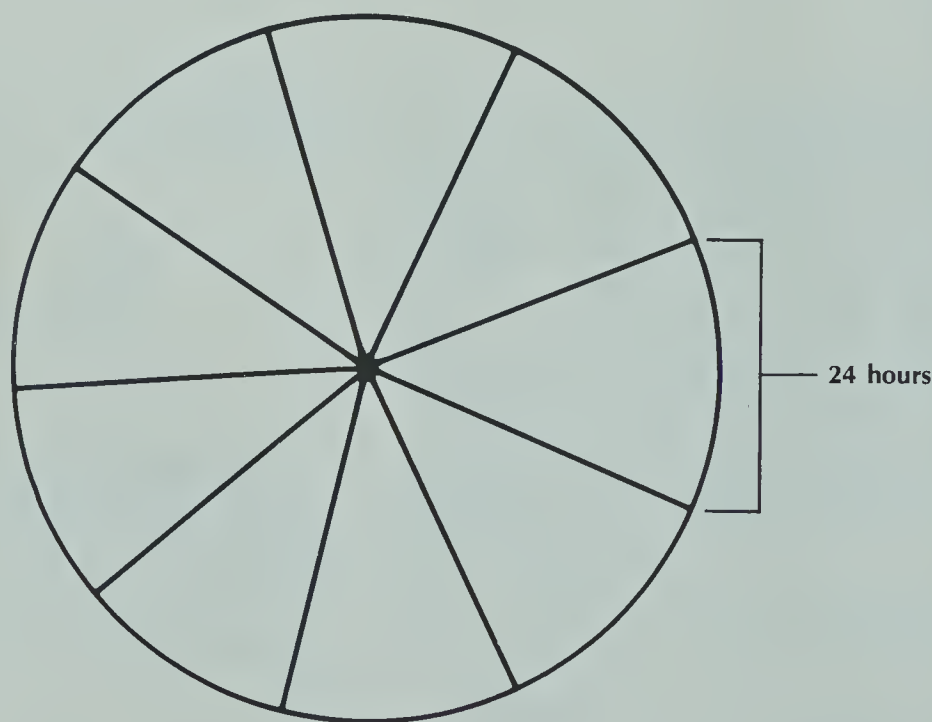
Analysis

1. List the stages of development of a fruit fly in proper order. _____
2. How does development differ from growth? _____

3. The amount of time a fruit fly spends in each of its various stages is listed here. These values are correct if development occurs at 25°C.

Egg—24 hours; larva—96 hours; pupa—96 hours

Prepare a pie graph of these values. (Each pie slice is equal to 24 hours.) Shade in a pie section corresponding to the amount of time spent in the egg stage. Leave the pie section corresponding to the amount of time spent in the larval stage blank. Use vertical lines to mark the pie sections corresponding to the amount of time spent in the pupa stage.



4. (a) What might happen to total development time if the temperature were to drop below 25°C?

(b) Explain. _____

PROTEIN DIGESTION

60

Protein digestion in humans normally takes place in the stomach and small intestine. Enzymes in these organs break down protein into a useable form. Can protein digestion occur in a test tube if these same enzymes are provided? This question is to be answered in this investigation. The enzyme pepsin will be added to boiled egg white (protein). If digestion does take place, the egg white will change into a transparent (clear) liquid protein.

In this investigation, you will

- prepare egg white protein in capillary tubes.
- add different combinations of enzyme and hydrochloric acid to the tubes.
- determine if protein digestion has occurred by observing the change in the egg white in the capillary tubes.

Materials

test tubes—4
glass marking pencil (wax)
water
graduated cylinder
pepsin solution
glass tubing (capillary thickness)—6 cm long

metric ruler
petri dish
raw egg white
file
hydrochloric acid
hot plate

Procedure

- Using a hot plate, boil water in the bottom of a petri dish. **CAUTION:** *Glass and plate are hot. Do not touch with unprotected hands.*

- Draw raw egg white into a glass capillary tube by using the tube like a straw. **CAUTION:** *Watch out for rough glass edges. Be sure the end of the tube is smooth before using.* Use Figure 60-1 as a guide.

- Place the tube into the boiling water for a minute or until all egg white is cooked (a white solid appears).

- Remove the capillary tube from the water with tweezers. Cut the tube into fourths by scratching the glass tubing with a file and then snapping the tube. (Your teacher will explain this procedure in detail.)

NOTE: Each of the four prepared tubes must have egg white filled completely to the ends. If some egg white was pulled out when snapping the glass, prepare new tubes.

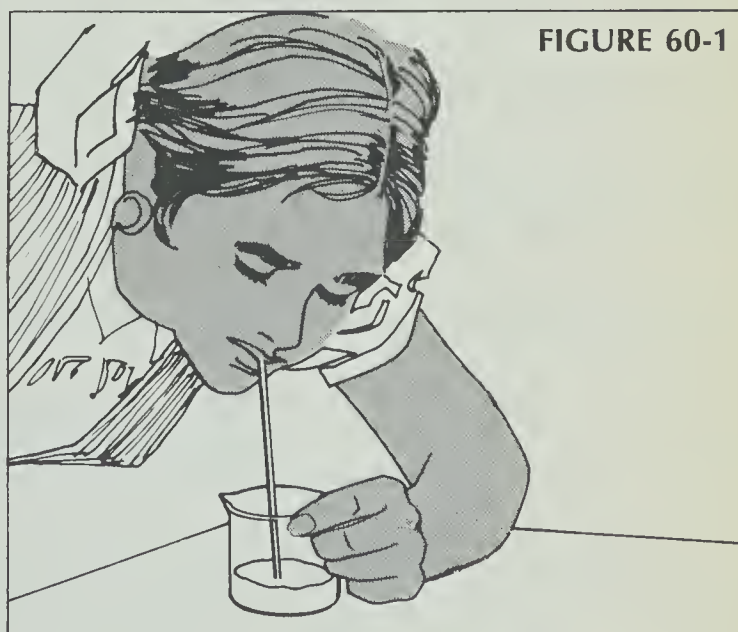
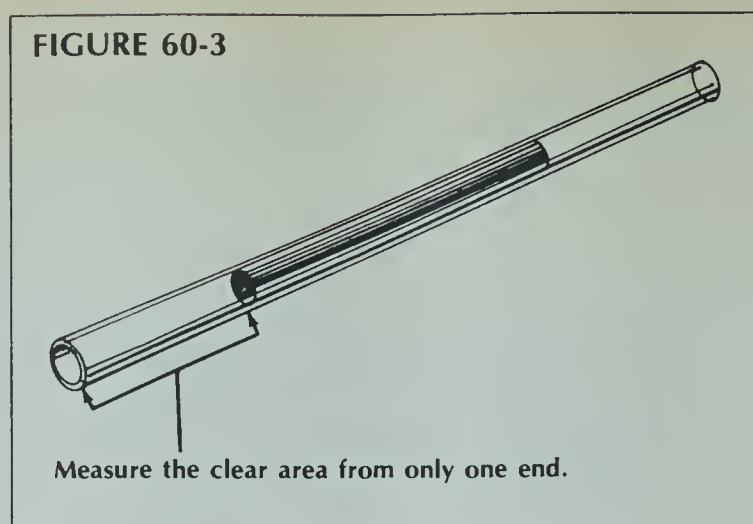
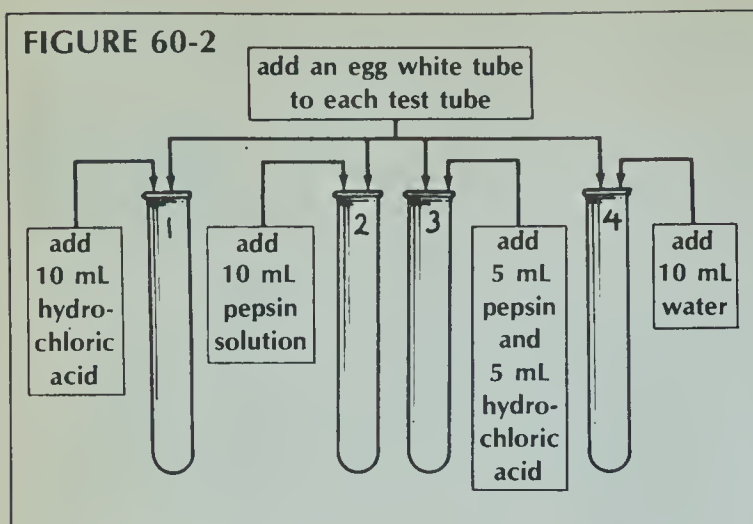


FIGURE 60-1

- Label four test tubes one to four. Fill the tubes as shown in Figure 60-2.

CAUTION: *Acid is harmful to skin and clothing. Rinse with water if spillage occurs. Call your teacher.*



● Place all tubes aside. Examine 24 or 48 hours later.

● After 24 or 48 hours, remove the egg white tubes from the test tubes. NOTE: Tubes one and three should have their contents (acid) slowly poured into a sink. Rinse the tube with water twice before removing the egg tube. Record in Table 60-1 the length in millimetres of clear, digested protein at one end of each egg white tube. NOTE: Change in the egg protein from a white solid to a clear liquid is an indication that digestion has occurred. Use Figure 60-3 as a guide in measuring.

TABLE 60-1. EVIDENCE OF PROTEIN DIGESTION

TUBE	PROTEIN DIGESTION LENGTH (mm)	CONTENTS OF TUBE
1		
2		
3		
4		

Analysis

- (a) What was used in this investigation as the protein? _____

(b) Why was pepsin used in this experiment? _____
- (a) Which tube shows the greatest amount of protein digestion? _____

(b) What chemicals were added to this tube? _____
- (a) Which tube shows a moderate amount of digestion? _____

(b) What chemicals were added to this tube? _____
- (a) Which tube (excluding 4) shows no protein digestion? _____

(b) What chemicals were added to this tube? _____
- (a) What chemicals found in the stomach aid protein digestion? _____

(b) Which test tube is most similar to the stomach in contents? _____
- What experimental evidence is there to show that pepsin digests better in an acid environment? _____
- What experimental evidence is there to show that acid alone is not responsible for protein digestion? _____

FAT DIGESTION

61

Digestion is a process in which fats, proteins, and carbohydrates are changed chemically into less complex molecules. These changes usually are caused by the chemical action of enzymes. Enzymes are produced by many organs of the digestive system. Digestion can occur in a test tube with the proper chemicals supplied. Color changes in certain chemicals can show if digestion has occurred.

Litmus is a chemical that can be used to show if fat digestion has occurred. Litmus in the presence of fat is blue. Litmus is pink in an acid environment. When fat is digested, it is changed into fatty acids. Litmus changes to dark pink and then to light pink if the fat is broken down into fatty acids. This color change can, therefore, show if fat digestion has occurred.

In this investigation, you will

- (a) use litmus to determine if fat (cream) digestion occurs.
- (b) determine how steapsin and bile affect fat digestion rate.

Materials

test tubes—3
glass marking pencil (wax)
cream
litmus solution
bile solution

steapsin solution
water
graduated cylinder
dropper
stoppers—3

Procedure

- Label three test tubes one to three.
- To each of the three tubes, add 10 mL of water, one drop of cream, and 10 drops of litmus.
- Mix the contents of each tube.
- Record the exact color of each tube in the column marked "at start" in Table 61-1. Use these colors: blue, dark pink, light pink.
- To tube two, add 20 drops of steapsin enzyme.
- To tube three, add 20 drops of steapsin enzyme and five drops of bile.
- Mix the contents of each test tube by placing a stopper over the opening and inverting the test tube.
- Set the tubes upright and wait ten minutes.

TABLE 61-1. FAT DIGESTION RESULTS

	DROPS OF STEAPSIN	DROPS OF BILE	COLOR		
			AT START	10 MINUTES LATER	20 MINUTES LATER
Tube 1	0	0			
Tube 2	20	0			
Tube 3	20	5			

● At the end of ten minutes, mix again and observe the color within each tube. Hold the test tubes toward the light to observe the color changes. Because color changes may not be readily apparent, compare each solution with the other solutions. Record the colors (use only blue, dark pink, or light pink) in Table 61-1.

● At the end of twenty minutes, mix again and observe the color of each tube. Hold the test tubes toward an artificial light source to observe the color changes. Because changes may not be readily apparent, compare each solution with the other solutions. Record the colors in Table 61-1. (Use only blue, dark pink, or light pink.)

Analysis

1. (a) What was used in this experiment as the fat? _____
(b) Why was steapsin used in this experiment? _____
(c) What was the purpose of using litmus in this experiment? _____

2. (a) Which test tube showed the lightest pink color after twenty minutes? _____
(b) Which test tube showed the most fat digestion after twenty minutes? _____
(c) What chemicals were added to this tube? _____
3. (a) Which test tube showed only a dark pink color after twenty minutes? _____
(b) Which test tube showed only some fat digestion after twenty minutes? _____
(c) What chemicals were added to this tube? _____
4. (a) Which test tube remained blue in color after twenty minutes? _____
(b) Which test tube showed no fat digestion after twenty minutes? _____
(c) What chemicals were added to this tube? _____
5. (a) What is the function of enzymes in the human body? (Consult your text.) _____

(b) What is the function of bile in the human body? _____

6. Which test tube contained those chemicals most similar to those found in the intestine during fat digestion? _____
7. What experimental evidence do you have to show that bile helps speed up fat digestion? _____

8. What experimental evidence do you have to show that bile is not needed in fat digestion? _____

DIGESTIVE SYSTEM OF FROG AND HUMAN

62

No two animal types have exactly the same internal organs. However, animals in the same phylum should have organs that are somewhat similar. Frogs and humans are both chordates, and their internal organs, especially those of the digestive system, are similar. Thus, if you study the structures of the digestive system of a frog, it will help you better understand the structures of the human digestive system.

In this investigation, you will

- observe the digestive organs of a dissected frog.
- compare your observations of the frog's digestive system with diagrams of the human digestive system.
- determine similarities and differences in structures between the systems of these two animals.

Materials

frog, preserved
dissecting pan
scissors

pins
tweezers
hand lens

Procedure

Part A. Digestive System, External Parts

One can think of the digestive system as a long hollow tube extending through the body. This tube is open to the outside at both ends. One opening is called the mouth. The other opening in a frog is called the cloaca.

- Examine the mouth of your frog. The mouth can be opened more easily by cutting the edges of the jaw with scissors. **CAUTION:** Always be careful when using scissors. Use Figure 62-1 as a guide.

FIGURE 62-1

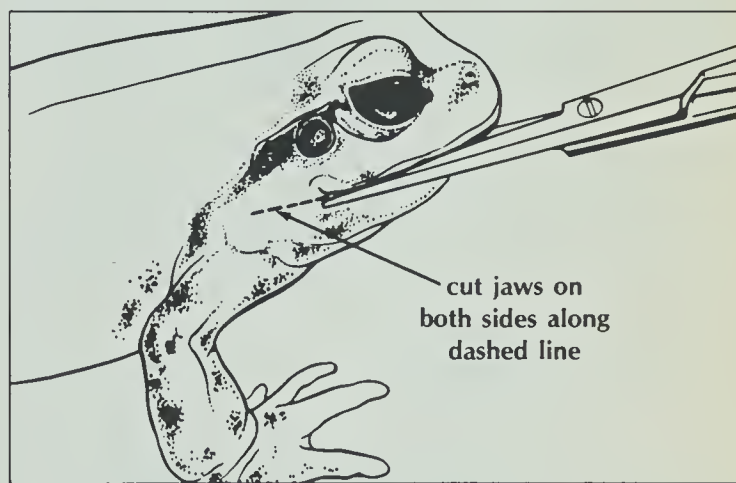


FIGURE 62-2

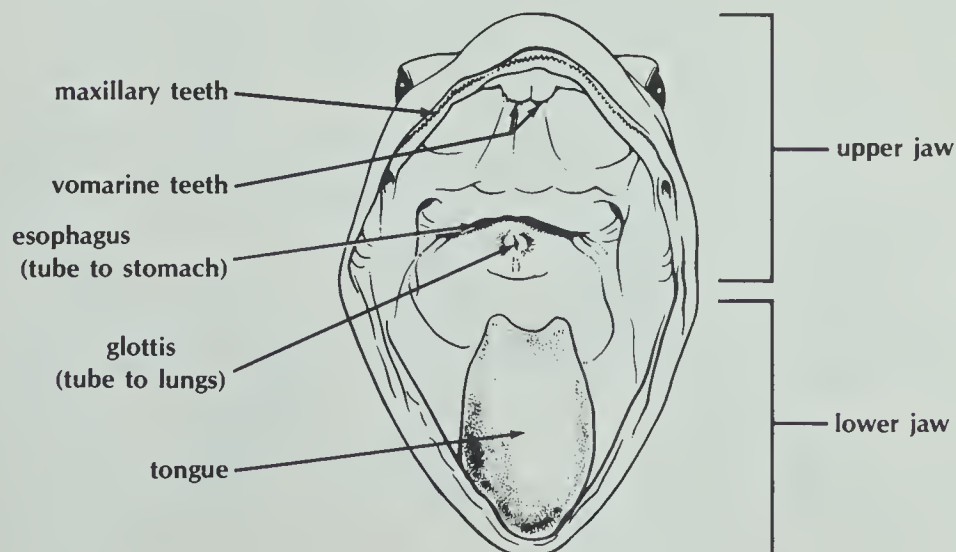
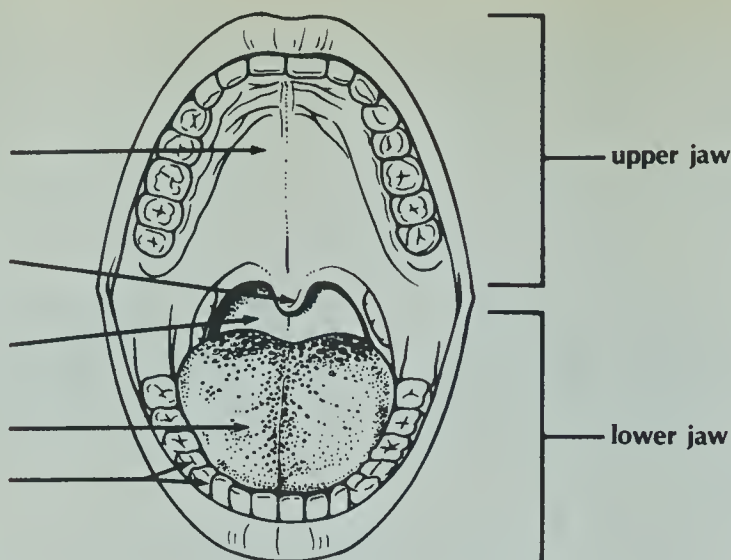


FIGURE 62-3



- Locate the five structures of a frog mouth using Figure 62-2 as a guide.

- Rub your finger along the inside edge of the frog's upper jaw. You should feel the maxillary teeth.

1. Are any maxillary teeth also felt along the lower jaw edge? _____

Use Figure 62-3 as a guide to the human mouth. Label the following parts: *teeth*, *pharynx* (space at back of mouth), *palate* (roof of mouth), *uvula* (small fleshy flap hanging from palate), *tongue*.

2. Compare the frog's tongue to the human's.

(a) How do the tip ends differ? _____

(b) How do the points of attachment to the lower jaw differ? _____

3. Compare the frog's teeth to the human's.

(a) How do the number of teeth differ? (Estimate the number of maxillary teeth in the frog.) _____

(b) How does their location differ? _____

(c) How might their functions differ? (Frogs swallow their food whole.) _____

4. Can one easily see the esophagus and glottis in the human mouth? _____

Part B. Digestive System, Internal Parts

- Place your frog on its back in a dissecting pan.

- Use Figure 62-4 and the numbered steps as a guide to dissection.

- *Step 1.* Use scissors to cut through the skin along the dashed lines.

- *Step 2.* Use tweezers to peel skin back to expose muscle.

- *Step 3.* Cut through muscle using same dashed lines as for skin. This process should form two flaps.

- *Step 4.* Pin skin and muscle flaps to the animal's sides thus exposing its internal organs.

NOTE: If your frog is female and contains black eggs, they must be carefully removed before other organs can be observed. The first organ that can be seen near the top of your opened frog is the liver. The liver appears brownish grey in color and consists of several large sections or lobes.

FIGURE 62-4

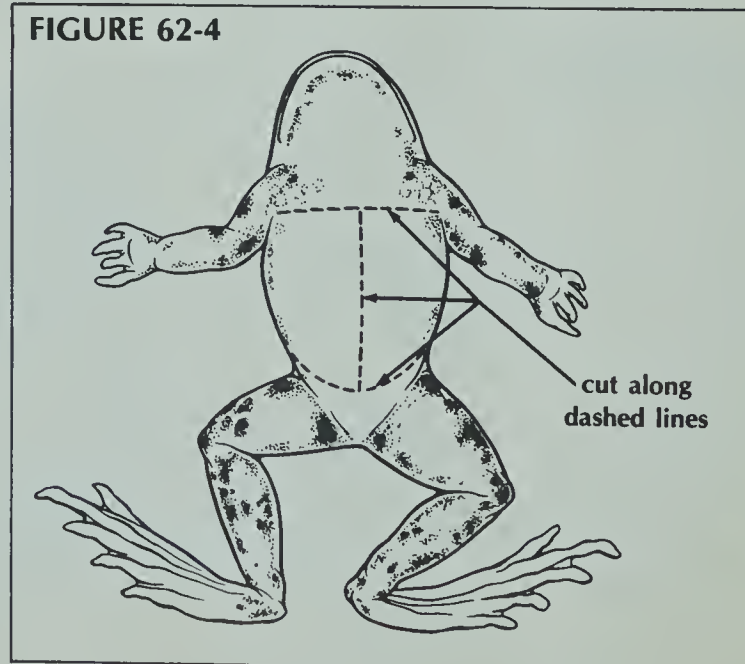







TABLE 62-1. INTERNAL ORGANS OF A FROG

ORGAN	APPEARANCE	DESCRIPTION
Liver and Gall Bladder		Large, in 3 sections, at top of incision. Lift liver in order to see the gall bladder (green sac).
Stomach		Large muscular organ occupying most of the inner cavity. Toward the right of the frog.
Pancreas		Thin strand of tissue lying just above stomach. (Not easily seen.)
Small Intestine		Thin tubelike coils. Toward left side of frog.
Large Intestine and Cloaca		Near bottom of incision. Wide organ connected to small intestine. Cloaca is opening to outside of body.

● Use your thumb to lift the free end of the liver up. This will reveal most of the digestive organs. Use Table 62-1 to help identify organs of the digestive system.

● Complete Figure 62-5 using the organ names appearing in Table 62-1.

The following should be noted inside your frog:

- the small intestine is held together in a tight coil by a very thin, almost tissue paper-like membrane called the mesentery.
- many blood vessels can be seen in the mesentery connecting to the small intestine.
- there is no appendix.

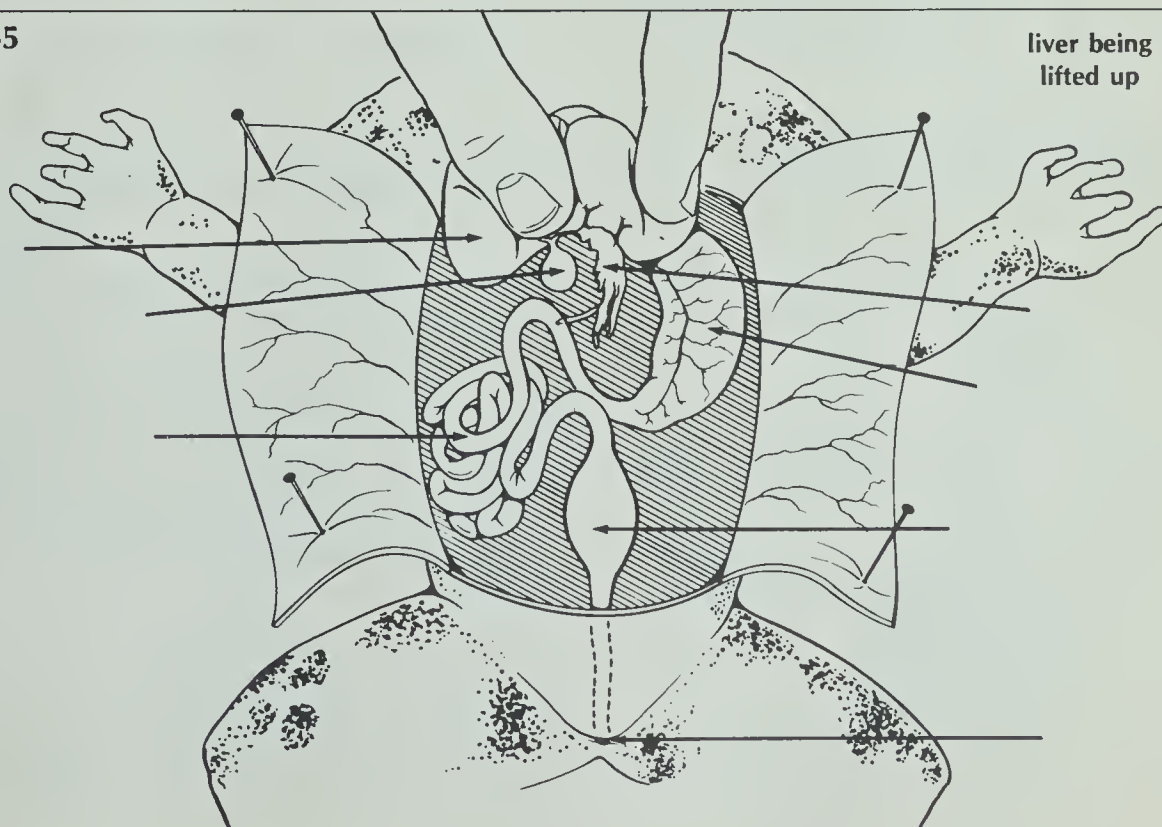
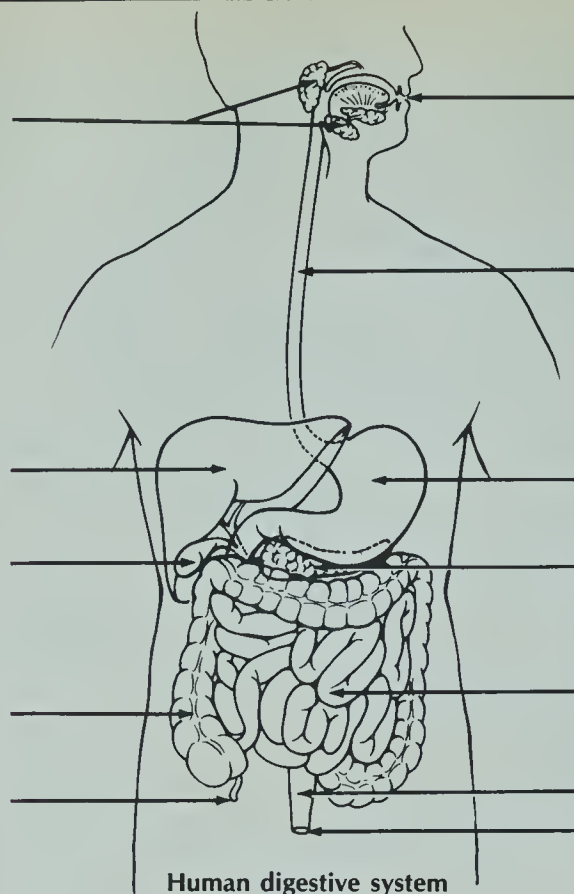
FIGURE 62-5

FIGURE 62-6



Human digestive system

● Examine Figure 62-6 showing a diagram of the human digestive system.

Before labeling its parts, note the following:

- (a) gall bladder and pancreas both connect by narrow tubes to the small intestine. Chemicals or enzymes formed or stored by these organs can empty into the small intestine.
- (b) large intestine consists of three main sections instead of just one in frogs.

● Label these parts: *liver, gall bladder, pancreas, stomach, small intestine, large intestine*. (Dashed lines indicate organs which lie below other organs.) Several parts not labeled or present on the frog diagram are shown in the human diagram. Label these five new parts:

- (a) *mouth*—opening to digestive system.
 - (b) *esophagus*—tube leading from back of mouth to stomach.
 - (c) *salivary glands*—small glands under tongue and in back of mouth connecting to mouth by way of narrow tubes.
 - (d) *appendix*—fingerlike part where small and large intestines join.
 - (e) *rectum*—connects large intestine to anus. (Replaces cloaca of frog.)
 - (f) *anus*—opening to outside at end of rectum.
5. Compare the frog stomach to the human's.

(a) How do their shapes differ?_____

(b) How might their functions differ?_____

6. (a) Does the same part lead from mouth to stomach in both frog and human?_____

(b) Name this part._____

7. Compare the frog large intestine to the human's.

(a) How do their shapes differ?_____

(b) Are both connected at one end to small intestine?_____

Part C. Parts of the Alimentary Canal

Certain digestive organs are like hollow tubes. Food is pushed through these hollow organs as digestion takes place. Other digestive organs are solid and food does not pass through them. Instead, these solid organs supply the hollow ones with enzymes or chemicals needed for digestion. The hollow organs through which food passes are said to be part of the body's alimentary canal. The first organ of the human or frog alimentary canal is the mouth.

● Determine which organs of the frog are or are not part of the alimentary canal. Use scissors (or single-edged razor blade) to remove a small section of liver, small intestine, stomach and large intestine.

● Examine each organ section with a hand lens and determine if it is hollow or solid. Record your results in Table 62-2.

● In the last column of Table 62-2, check those organs which are part of the alimentary canal. Note that certain organs have already been completed for you in the table. (Salivary glands are only present in the human.)

TABLE 62-2. ORGANS OF THE ALIMENTARY CANAL		
DIGESTIVE ORGAN	HOLLOW OR SOLID?	PART OF ALIMENTARY CANAL?
Salivary glands	Solid	
Mouth	Hollow	✓
Esophagus	Hollow	✓
Stomach		
Liver		
Pancreas	Solid	
Small intestine		
Large intestine		

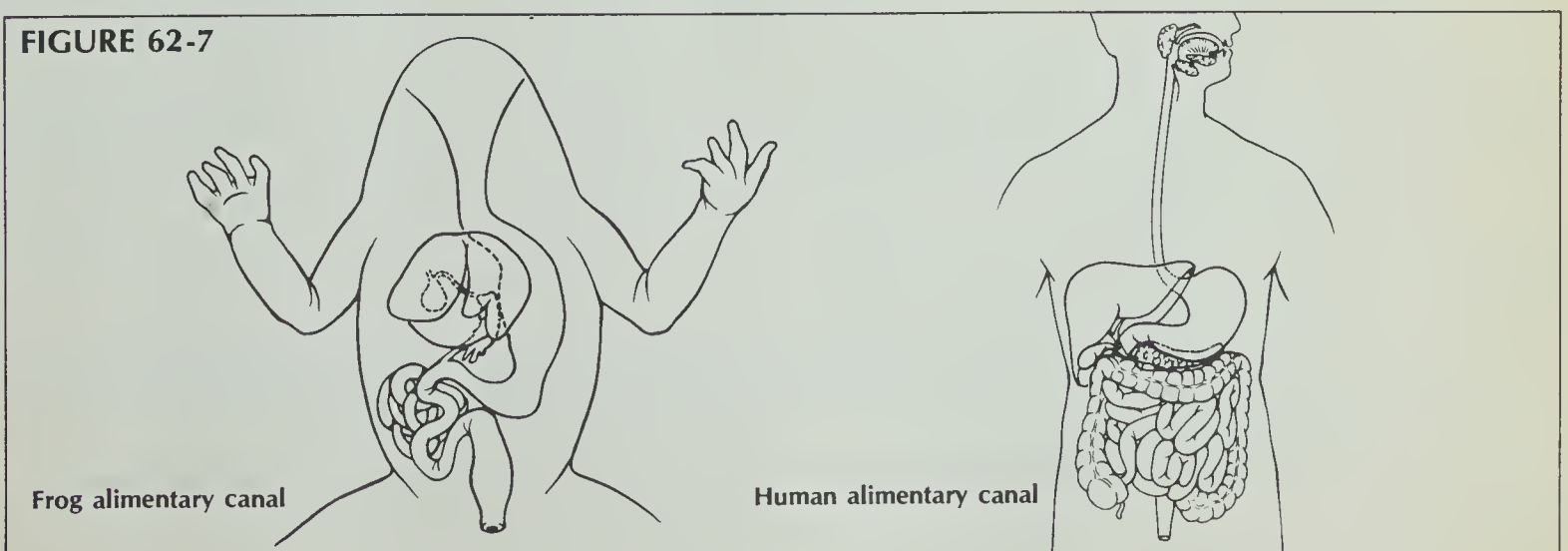
Analysis

1. Digested food is absorbed into the bloodstream while it is in the small intestine. What structure seen in the frog small intestine helps absorb food at this point? _____

Explain your answer. _____

2. Shade in on the diagrams in Figure 62-7 only those organs which make up the alimentary canal of a frog and human.

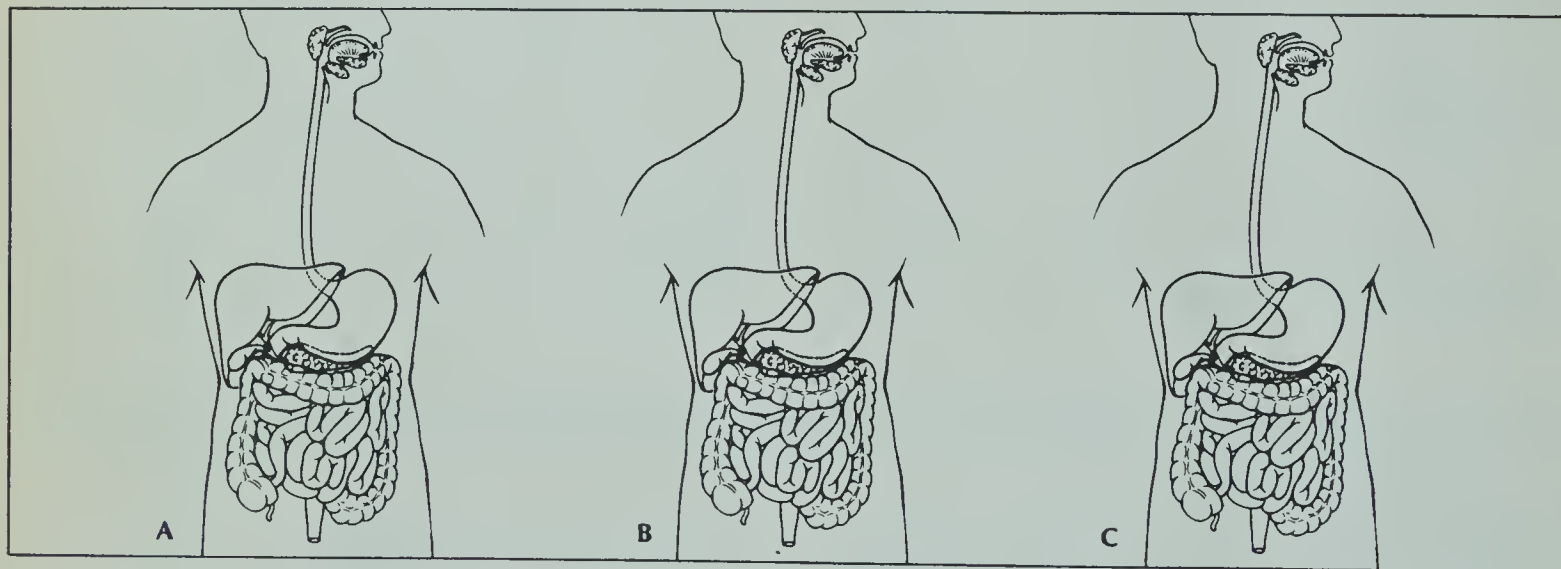
FIGURE 62-7



3. (a) The liver makes a chemical called bile. Bile is stored in the gall bladder. How does bile reach the small intestine? _____
- (b) The pancreas makes several enzymes needed for digestion. How do these enzymes reach the small intestine? _____
4. Table 62-3 shows the various organs of the digestive system as well as the types of food acted upon by these organs.

TABLE 62-3. ORGANS OF THE DIGESTIVE SYSTEM	
ORGAN	FOOD TYPE ACTED UPON
mouth and salivary glands	carbohydrates
esophagus	none
stomach	protein
liver and gall bladder	fat
pancreas	fat, protein, carbohydrates
small intestine	fat, protein, carbohydrates
large intestine	none

- (a) On diagram A below, shade in all organs which aid in carbohydrate digestion.
- (b) On diagram B below, shade in all organs which aid in fat digestion.
- (c) On diagram C below, shade in all organs which aid in protein digestion.



5. (a) On the basis of your shaded diagrams in both questions 2 and 4, which organ is probably the most important for digestion? _____
- (b) Why? _____
- (c) Why might the pancreas be considered to be the second most important organ of digestion and not the stomach? _____

THE HUMAN HEART

63

Heart muscle tissue contracts and relaxes to pump blood throughout your body. The blood, carrying oxygen and other materials, moves through the circulatory system which is composed of arteries, capillaries, and veins.

In this investigation, you will

- (a) follow the pathway of blood through the heart.
- (b) determine the amount of oxygen or carbon dioxide contained in blood in each side of the heart.
- (c) follow the sequence of events occurring as a heart beats.
- (d) measure blood pressure differences in arteries and veins using a heart-blood vessel model.

Materials

plastic bottle
2-hole stopper to fit bottle
metric ruler
glass tube, 3 cm long
glass tube, 18 cm long
plastic tube, 15 cm long

Procedure

Part A. Heart Anatomy and Blood Flow

Study Figure 63-1 to determine the names and locations of all major blood vessels and heart structures. This diagram is a front view of the heart, which makes the labels indicating left and right sides appear to be reversed. All shaded areas are muscle. Unshaded areas are filled with blood.

- Complete Table 63-1 indicating the direction of blood flow.

1. Blood moves to two organs from the right side of the heart. What are these organs? _____

2. Blood is received from two organs on the left side of the heart. What are these organs? _____

Part B. Condition of Blood as it Flows Through the Heart

All vessels bringing blood to the heart's right side and leaving from the right ventricle contain blood that is deoxygenated. Deoxygenated blood is low in oxygen and high in carbon dioxide.

All vessels bringing blood to the heart's left side and leaving from the left ventricle contain oxygenated blood. Oxygenated blood is high in oxygen and low in carbon dioxide.

- Complete Table 63-2 indicating the oxygen content of blood. Use the terms "deoxygenated" and "oxygenated." Refer to Figure 63-1 for help.
3. (a) Describe the condition of blood in all parts of the right side of the heart. _____
(b) Describe the condition of blood in all parts of the left side of the heart. _____

FIGURE 63-1

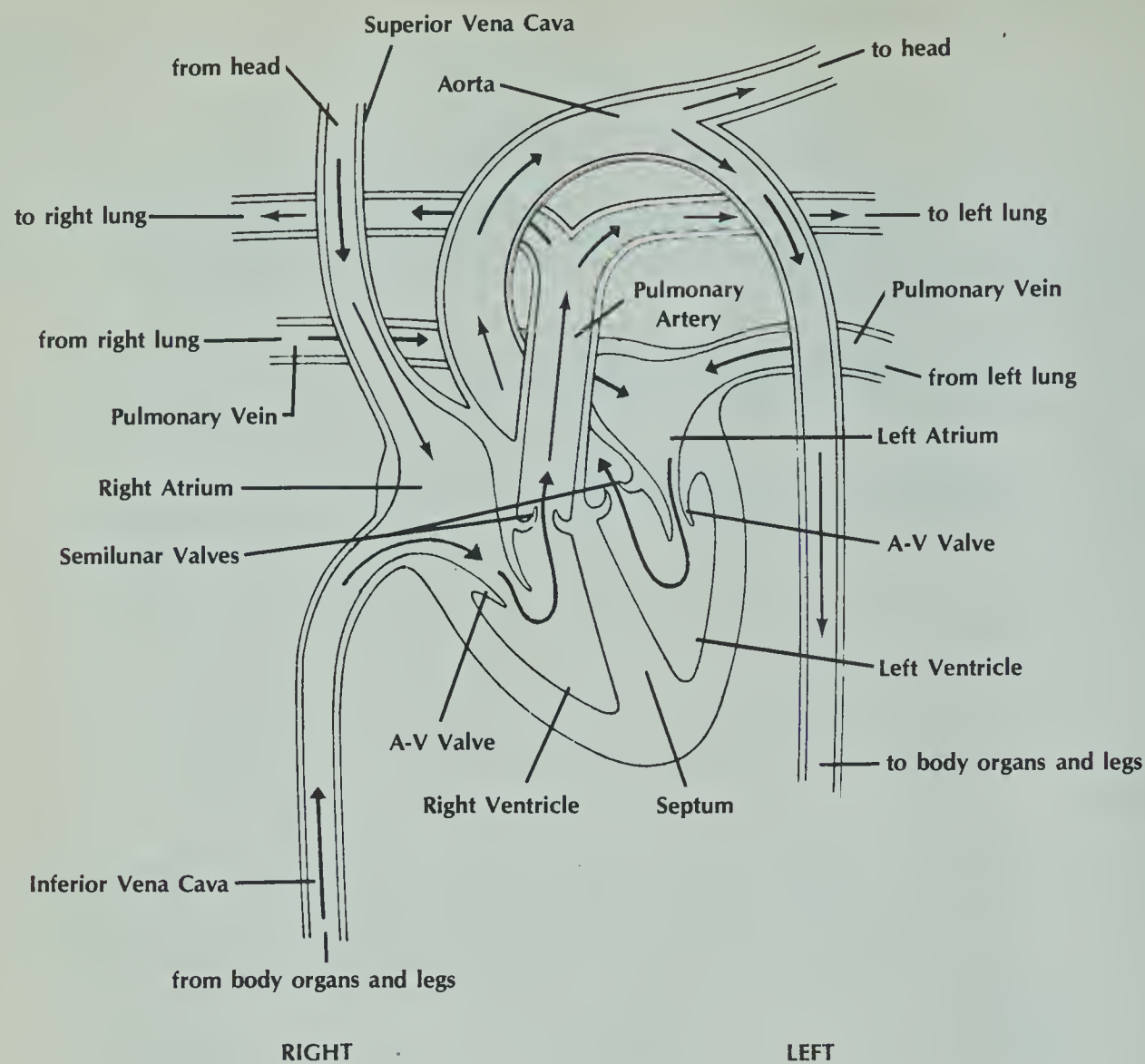


TABLE 63-1. BLOOD FLOW

RECEIVES BLOOD FROM	
left side	1. 2.
right side	1. 2.
PUMPS BLOOD TO	
left side	1. 2.
right side	1. 2.

TABLE 63-2. OXYGEN CONTENT OF BLOOD

CHAMBER OR VESSEL	OXYGENATED OR DEOXYGENATED
Left ventricle	
Right ventricle	
Left atrium	
Right atrium	
Pulmonary artery	
Pulmonary vein	
Superior vena cava	
Inferior vena cava	
Aorta	

Part C. Heart Pumping Action

In order to move blood through the heart, a pumping action must occur. It is the ventricles that aid in the pumping action of the heart. Heart valves keep the blood flowing in one direction as the ventricles squeeze or pump blood through the heart.

● Examine Figure 63-2 showing the ventricles relaxed and not pumping blood. This relaxed condition is called diastole.

● Complete the left column of Table 63-3 while looking at Figure 63-2.

● Examine Figure 63-3 showing the ventricle sides pushing in and squeezing and pumping blood out of the heart. This pumping action is called systole.

● Complete the right column of Table 63-3 by looking at Figure 63-3.

4. (a) During diastole, are the ventricles filling or being emptied of blood? _____
 (b) During systole, are the ventricles filling or being emptied of blood? _____

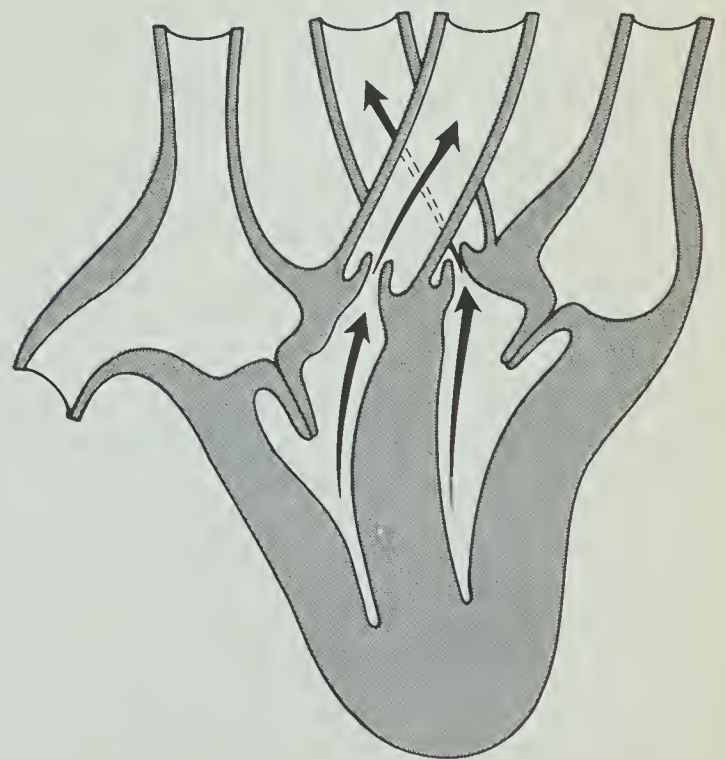
FIGURE 63-2



TABLE 63-3.		
	VENTRICALS IN	
	DIASTOLE	SYSTOLE
relaxed or pumping		
A.V. valves open or closed*		
blood flowing past A.V. valves?		
blood flowing into ventricles from atria?		
semilunar valves open or closed?*		
blood flowing past semilunar valves?		
Is blood flowing out of ventricles into aorta or pulmonary artery?		
*Valves are open if their tips are not touching.		

A continuous pattern of diastole and systole allows the heart to pump blood to all parts of the body. The heart relaxes and fills with blood, then pumps. It relaxes again while it refills, and then pumps again. You detect this pattern of relaxing and pumping when you feel your pulse.

FIGURE 63-3



Part D. Blood Pressure Model

Blood is under pressure as the heart pumps it through your body. The amount of pressure, however, varies throughout your body. Blood vessels called arteries have thicker walls and are less flexible. Arteries have blood under high pressure. Other blood vessels, veins, have blood under low pressure because of their thinner, more flexible walls and because of the loss of pressure that occurs as blood passes through the capillaries.

- Secure a plastic bottle from your teacher.
- Fill it with water and seal it with the provided rubber stopper and tube assembly. The finished apparatus should look like Figure 63-4. Note that one of the tubes leading from the stopper is glass while the other is plastic.

5. (a) Which tube represents the flexible blood vessel? _____

(b) Which tube represents the inflexible blood vessel? _____

- Position the plastic bottle assembly near the edge of a sink. Place a metric ruler into the sink as shown in Figure 63-5.

- Give the plastic bottle one firm squeeze. Measure the distance in millimetres that the water streams shoot out of the ends of the tubes. It is best to measure where the streams strike the bottom of the sink.

- Record the distances in Table 63-4 using the Trial 1 row.

- Repeat the squeezing and measuring four more times. Calculate an average distance for each tube.

A tube having more flexible sides will have a lower pressure. A tube having less flexible sides will have a greater pressure. The higher the pressure, the farther a stream of water will shoot from a tube. The lower the pressure, the shorter a stream of water will shoot from a tube.

6. (a) Which tube has the longer average stream of water? _____

(b) Which tube has the shorter average stream of water? _____

7. (a) Which tube has the higher pressure within it? _____

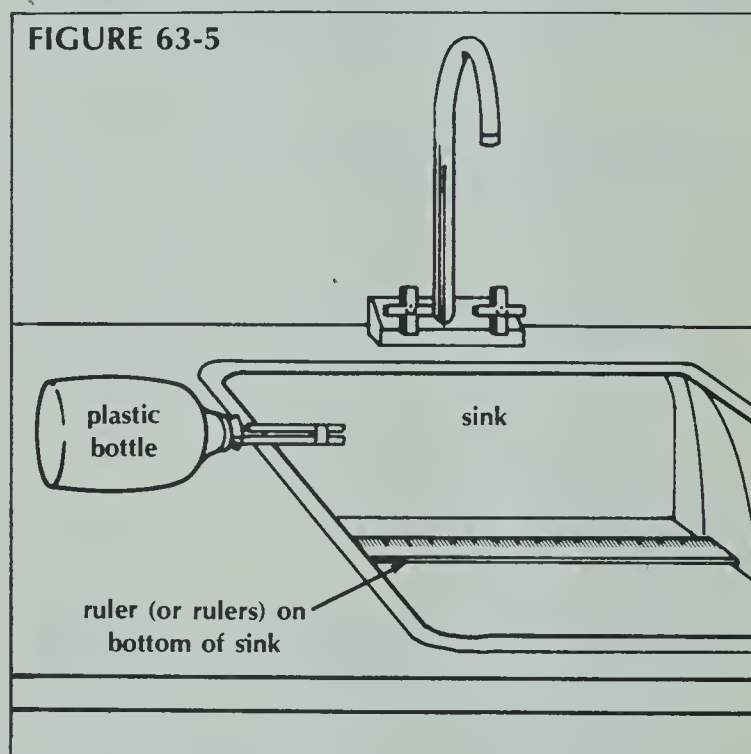
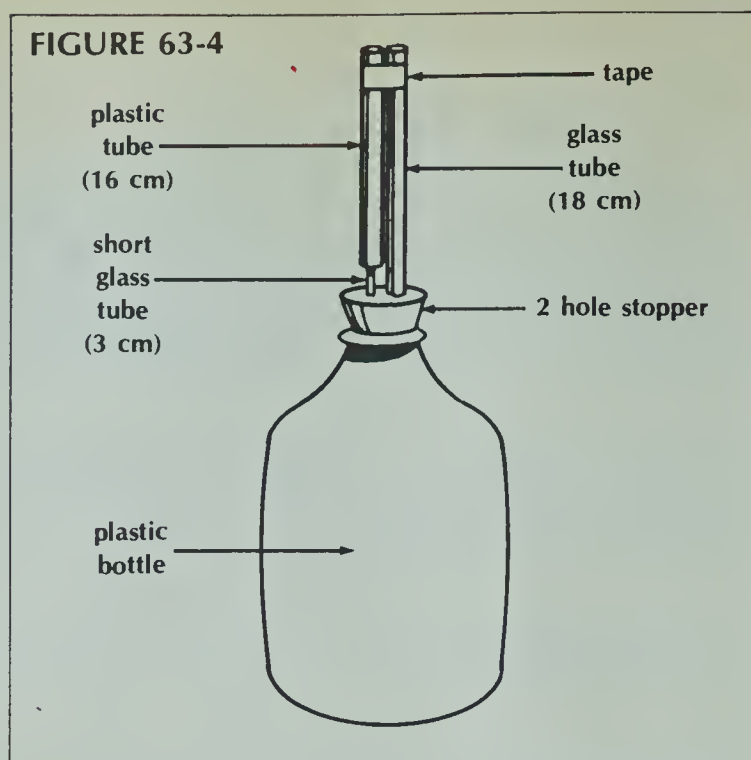


TABLE 63-4. EXPERIMENTAL RESULTS		
	GLASS TUBE	PLASTIC TUBE
Trial 1		
Trial 2		
Trial 3		
Trial 4		
Trial 5		
Totals		
Average Distance		

(b) Which tube has the lower pressure within it? _____

8. (a) Which tube represented an artery? _____

(b) Which tube represented a vein? _____

Analysis

1. Define the following terms:

(a) oxygenated blood _____

(b) deoxygenated blood _____

(c) systole _____

(d) diastole _____

2. Blood is changed from an oxygenated to a deoxygenated condition or vice versa in the circulatory system. Which change occurs in lung capillaries? _____

Which change occurs in body capillaries? _____

3. Using Figure 63-1 as a guide, tell where blood goes when it leaves the

(a) aorta. _____

(b) pulmonary artery. _____

(c) right and left atria. _____

4. Using Figure 63-1 as a guide, tell where blood comes from in each of the following structures.

(a) superior vena cava _____

(b) inferior vena cava _____

(c) pulmonary vein _____

5. Describe the direction of blood flow in the heart. _____

Does this type of flow help make pumping action efficient? _____

Explain. _____

6. Your heart ejects or pumps about 60 mL of blood into the aorta each time it undergoes systole.

(a) How many times in one minute does your heart pump (beat)? _____

(b) Calculate the amount of blood pumped by your heart in one minute. _____

7. (a) Assume that the AV valves were closed during diastole. What would happen to blood movement? _____

(b) Assume that the semilunar valves were closed during systole. What would happen to blood movement? _____

8. In Part D, what body part was represented by the

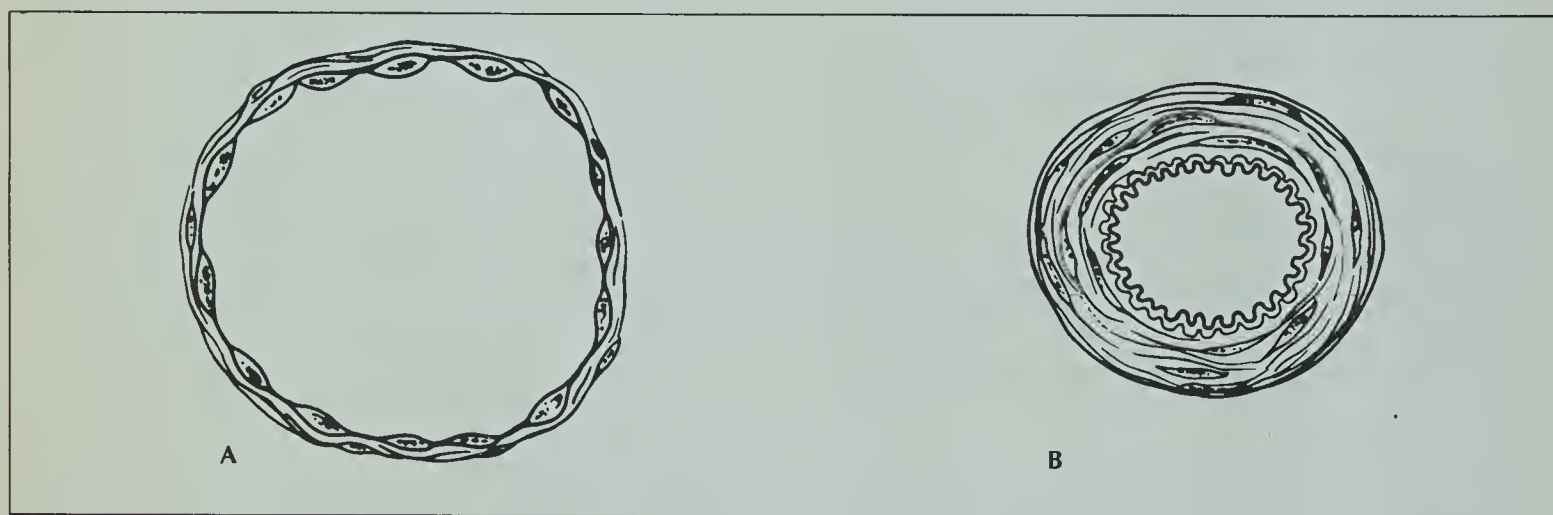
(a) plastic bottle? _____

(b) water in the bottle? _____

(c) plastic tube? _____

(d) glass tube? _____

9. A student observes the following cross section slices of blood vessels under the microscope.



(a) Which vessel is probably an artery? _____

Why? _____

(b) Which vessel is probably a vein? _____

Why? _____

BLOOD

64

Blood is a tissue made up of two different components, living cells and nonliving liquid. The cellular part has three different cell types, each having different functions or jobs. These three cell types are called red cells, white cells and platelets. The liquid part is called plasma.

In this investigation, you will

- (a) examine and diagram the three different blood cell types.
- (b) compare these three blood cell types as to appearance, function and occurrence.
- (c) examine blood plasma.
- (d) compare plasma to cell types in appearance, function and occurrence.

Materials

microscope
prepared slide of human blood (stained)
tube of blood

Procedure

Part A. Red Blood Cells

- Examine a prepared slide of human blood under low power. Locate the red blood cells. These cells are numerous and appear dotlike under low power. Red blood cells function in the transport of gases. They distribute oxygen and collect carbon dioxide throughout the body.
- Switch to high power and focus clearly on several red blood cells. They are pink and will be the most common cells in your field of view.
- Diagram one or two cells in the space provided in Table 64-1. Make the diagram the same size as the cells you see through the microscope.
- Label the following parts of the red blood cells: *cell membrane*, *cytoplasm*.
- Count the number of red cells present in your field of view and record this number in Table 64-1.

Part B. White Blood Cells

- While still using high power, slowly move your slide until you see one or two cells that appear totally different from red cells. They will usually appear blue due to a stain which has been added to your slide. Some may have tiny red or blue dots or granules within them. Some may have a horseshoe

shape or round, deep blue nuclei. These cells are white blood cells. White blood cells function in the immune system. They “fight off” bacteria and produce antibodies.

- Diagram one or two white blood cells in the space provided in Table 64-1. Make the diagram the same size as the cells you see through the microscope.
- Label the following parts of these cells: *cell membrane*, *cytoplasm*, *nucleus*.
- Count and record the number of white cells present in your field of view in Table 64-1.

Part C. Platelets

- While still using high power, examine your slide for very small, dotlike cell fragments that appear blue. These cell fragments are platelets. Platelets release chemicals which help blood clot when an injury occurs.
- Diagram one or two platelets in the space provided in Table 64-1. Make the diagram the same size as the cells you see through your microscope. Because platelets are cell fragments, do not label their parts.
- Count and record the number of platelets present in your field of view in Table 64-1.

Part D. Plasma

- Your teacher will have available a tube of blood. Examine this tube but do not shake or tip it. Do not remove the stopper.

Blood plasma appears toward the top of the tube. Plasma is the fluid portion of blood. It contains water, salts, digested foods, glucose, hormones, antibodies, and clotting proteins.

The red portion toward the tube's bottom are all the cellular parts. Red cells, white cells and platelets are all in the bottom of the tube.

- Using Figure 64-1, draw in the exact location and amount of plasma and cell parts in your tube.

- Label the following parts: *plasma*, *cellular portion*, *living blood part*, *nonliving blood part*.

TABLE 64-1. BLOOD CELL DIAGRAMS AND COUNTS		
CELL TYPE	DIAGRAM AND LABELS	NUMBER OF CELLS IN ONE FIELD
Red blood cell		
White blood cell		
Platelet		



Analysis

1. Using the number of cells recorded in Table 64-1, tell which cell type on your blood slide is

(a) most numerous. _____

(b) next most numerous. _____

(c) least numerous. _____

2. List a difference between red and white cells when comparing

(a) color (in stained cells). _____

(b) nucleus. _____

3. What is the major function of

(a) red blood cells? _____

(b) white blood cells? _____

(c) platelets? _____

4. Describe the color of plasma. _____

LUNG CAPACITY

65

Human lung capacity can be measured in several ways. One way is by using a piece of laboratory equipment called a spirometer. However, lung capacity also can be measured by using a balloon. The data you obtain may not be as accurate as that obtained using a spirometer.

Several different lung volume measurements can be made. The largest possible amount of air which can be exhaled after drawing in a deep breath is the vital capacity. The amount of air that remains in the lungs after exhaling normally but which can be expelled is the expiratory reserve. The amount of air taken in or expelled during normal breathing is about 500 cm^3 . This volume of air is called the tidal volume. A certain amount of air in the lungs cannot be expelled. This amount is the residual volume.

In this investigation, you will

- exhale into a balloon to measure your tidal volume, expiratory reserve, and vital capacity.
- convert balloon measurements to volume units by using a graph.
- compare your experimental data with lung capacity data obtained from a spirometer.
- explain why differences may exist between your experimental data and data provided for average lung capacities.

Materials

round balloon
metric ruler

Procedure

Part A. Vital Capacity

- Stretch a balloon several times.
- Take as deep a breath as possible. Then exhale all the air you can into the balloon and pinch the balloon closed to prevent air from escaping.
- Measure and record the diameter of the balloon in Column A of Table 65-1. Use Figure 65-1 as a guide for measuring balloon diameter.
- Deflate the balloon and run four more trials. Record the diameter of the balloon for each trial.

FIGURE 65-1

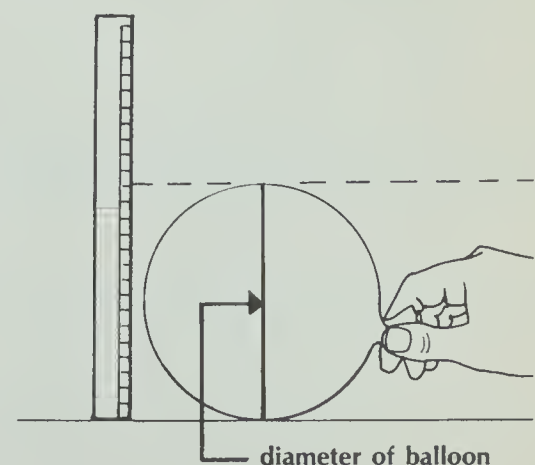


TABLE 65-1. BALLOON DIAMETERS AND LUNG VOLUMES

TRIAL	BALLOON DIAMETER IN CENTIMETRES			LUNG VOLUME IN CUBIC CENTIMETRES		
	A VITAL CAPACITY	B EXPIRATORY RESERVE	C TIDAL VOLUME	D VITAL CAPACITY	E EXPIRATORY RESERVE	F TIDAL VOLUME
1						
2						
3						
4						
5						
			Total			
			Average			

Part B. Expiratory Reserve

Read all of Part B before starting.

- Exhale normally.
- Without inhaling as you normally would, put the balloon in your mouth and exhale all the air still left in your lungs. NOTE: This step is different from what you did in Part A.
- Measure and record the diameter of the balloon in Column B of Table 65-1.
- Run four more trials. Record the diameter of the balloon for each trial.

Part C. Tidal Volume

- Take in a normal breath. Exhale into the balloon only as much air as you would normally exhale. DO NOT force your breathing.
- Record the diameter of the balloon in centimetres in Column C of Table 65-1.
- Run four more trials. Measure and record each balloon diameter in Table 65-1.

Part D. Conversion of Diameters to Volume

Lung volume is expressed in cubic centimetre units (cm^3). (1000 cm^3 is equal to a litre.)

- To convert from balloon diameter to volume, locate the balloon diameter on the horizontal axis of Figure 65-2. Follow this number up to the heavy line, then move across to locate the corresponding volume. For example, if your balloon diameter is 14.5 cm, then the corresponding lung volume is 1500 cm^3 . Use the dashed lines on Figure 65-2 as an example of how this procedure is done.
- Convert each diameter for vital capacity, tidal volume, and expiratory reserve to volume.
- Record the volumes in Columns D, E, and F of Table 65-1.
- Calculate and record your average lung volume for each of the three measurements.

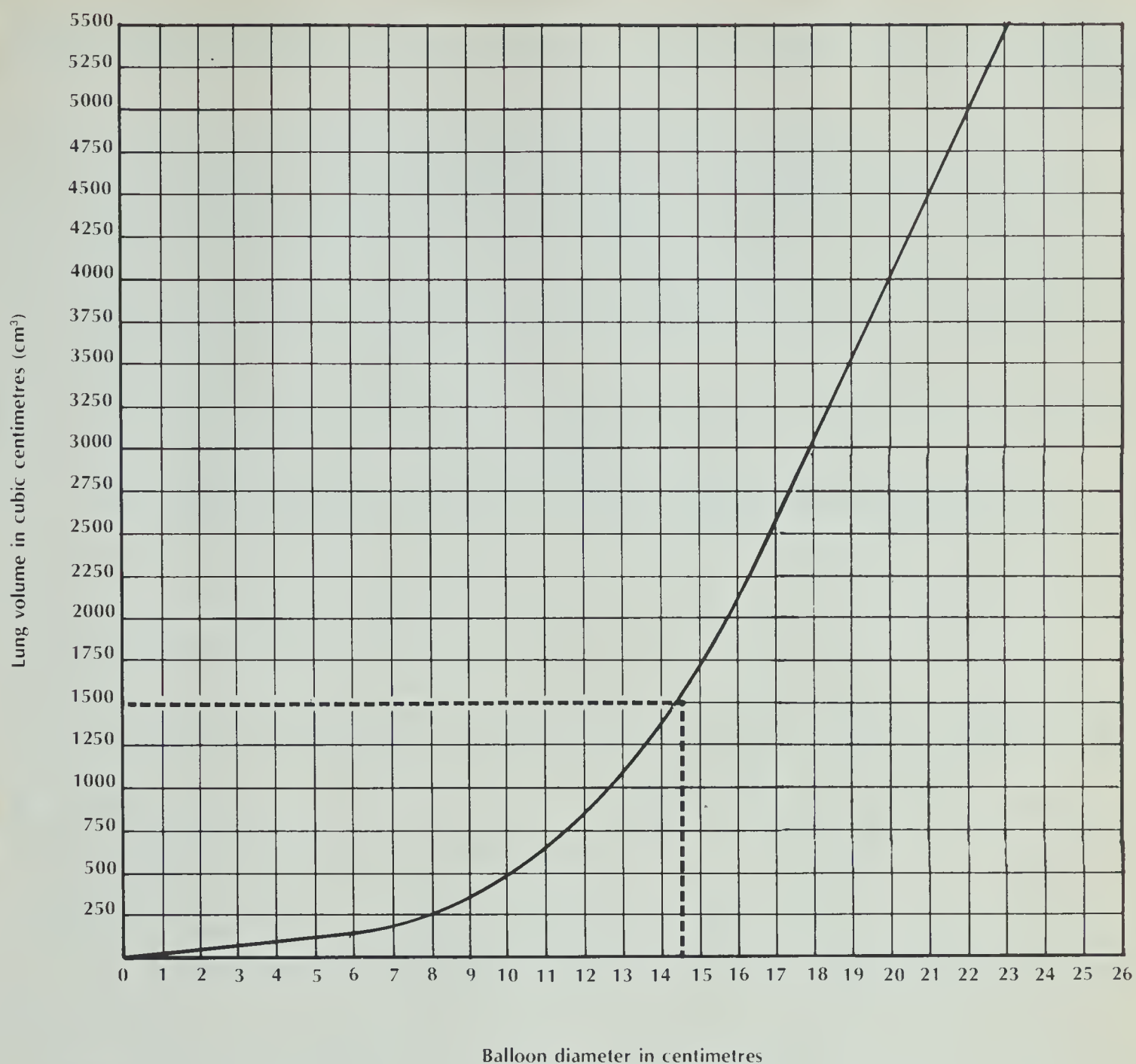


FIGURE 65-2

Analysis

1. Define the following terms:

(a) vital capacity _____

(b) expiratory reserve _____

(c) tidal volume _____

2. Using your average volume measurements in Table 65-1, record your measured

(a) vital capacity. _____

(b) expiratory reserve. _____

(c) tidal volume. _____

3. The following values were obtained through the use of a special machine called a spirometer. Note that these are average values.

TABLE 65-2. "AVERAGE" LUNG VOLUMES MEASURED WITH A SPIROMETER		
	MALE	FEMALE
Vital capacity	5000 cm ³	4000 cm ³
Expiratory reserve	1200 cm ³	1000 cm ³
Tidal volume	525 cm ³	475 cm ³

(a) How does your average vital capacity compare to the value obtained by a spirometer?

(b) Why might these numbers not agree? _____

(c) How could you improve the accuracy of this experiment without using a spirometer?

4. A close relationship between height and vital capacity exists. Complete this chart using your height for Column A and one of the following factors for Column B: 20 for females, 22 for female athletes, 25 for males, 29 for male athletes.

A YOUR HEIGHT IN CENTIMETRES	B FACTOR	C CALCULATED VITAL CAPACITY (A × B)

(a) Are your calculated and experimental values the same? _____

(b) Explain. _____

5. (a) What is your breathing rate for one minute? (Measure the number of times you breathe in or out in one minute.) _____

(b) How much air (in cm³) do you inhale in one minute? (HINT: Use your average tidal volume from Table 65-1.) _____

URINALYSIS

66

Kidneys are vital to life because they function in maintaining a normal balance of specific substances within the body. Many chemicals are excreted from your body in urine. Urine is made up of wastes from the body. These wastes include a poisonous substance called urea, as well as excess salts, sugar, and other chemicals. Doctors often test the chemical composition of urine. Chemicals that are either present or absent from urine can indicate whether or not certain body processes are occurring normally.

In this investigation, you will

- (a) learn how to run the chemical test for detecting the presence of glucose (sugar), chlorides (salts), albumin (protein), and phosphate.
- (b) perform these four tests on urine samples having known chemical makeup.
- (c) perform these four tests on urine samples having unknown chemical makeup.

Materials

hot plate
beaker (Pyrex)
water
Benedict's solution
glass marking pencil (wax)
urine with glucose, chlorides, albumin, phosphates
test tube holder
urine, unknown

urine without glucose, chlorides,
albumin, and phosphates
silver nitrate solution
graduated cylinder
Bunsen burner
acetic acid
test tubes—8

Procedure

Part A. Glucose (Sugar) Test

Benedict's solution changes from its original blue color to either green, yellow, orange, or red in the presence of glucose when heated. Benedict's solution remains its original blue color if no glucose is present.

- Prepare a hot water bath. **CAUTION:** *Do not handle hot plate or hot glass with unprotected hands.*
- Add 2 mL of Benedict's solution to each of two test tubes.
- Add 2 mL of urine *with* glucose to one of the test tubes.
- Add 2 mL of urine *without* glucose to the other test tube.
- Label the test tubes as to their contents.

- Put the test tubes into the hot water bath for five minutes.
- After five minutes, observe the colors of the solutions.
- Record in Table 66-1 the colors you observe.

Part B. Chloride (Salt) Test

Several drops of silver nitrate solution added to chlorides cause a white cloud (precipitate) to form in the liquid. If no chlorides are present, no white cloud will form.

- Add 5 mL of urine *with* chlorides to a test tube.
- Add 5 mL of urine *without* chlorides to another test tube.

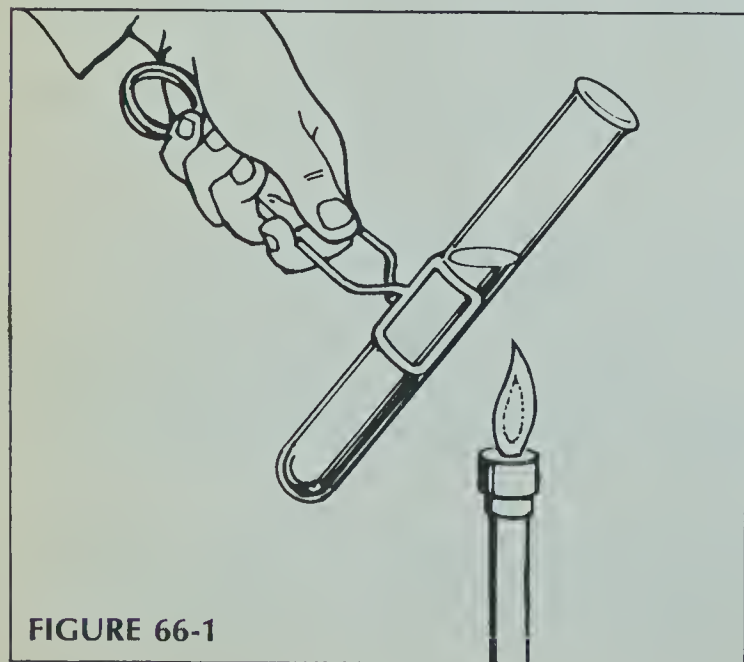
TABLE 66-1. RESULTS OF TESTS FOR SUBSTANCES IN URINE		
SUBSTANCE	CHANGE OBSERVED WITH SUBSTANCE PRESENT	CHANGE OBSERVED WITHOUT SUBSTANCE PRESENT
Glucose		
Chloride		
Albumin		
Phosphate		

- Label the test tubes as to their contents.
- Add two to three drops of silver nitrate solution to each of the test tubes. **CAUTION:** *Silver nitrate solution stains skin and clothing. If spillage occurs, rinse with water and call your teacher immediately.*
- Record in Table 66-1 the colors you observe.

Part C. Albumin (Protein) Test

If albumin is present in a urine sample, a haze will form in the top of the sample when only the top portion is heated. The haze will not disappear when acetic acid is added. If no albumin is present, no haze will form.

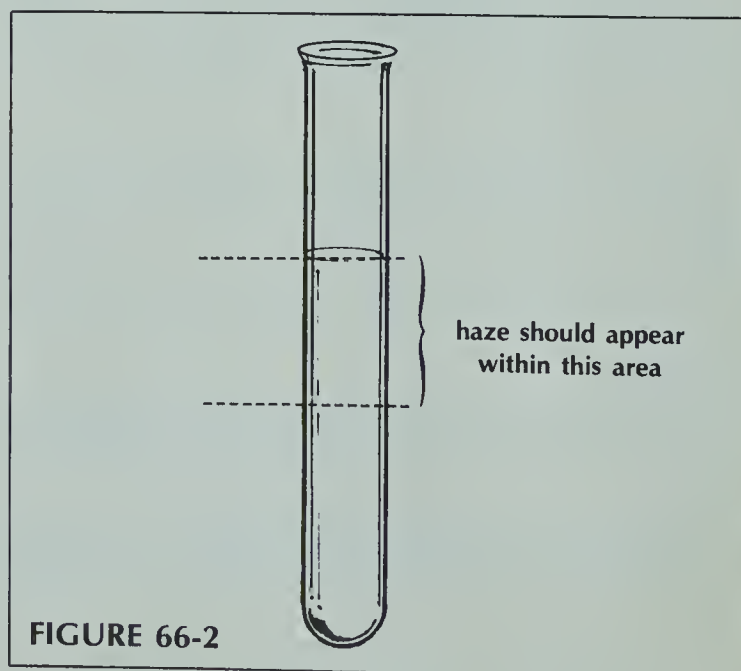
- Add $\frac{1}{2}$ test tube of urine *with* albumin to the first test tube.
- Add $\frac{1}{2}$ test tube of urine *without* albumin to a second test tube.
- Label the test tubes as to their contents.



- Heat only the top portion of each urine sample over a Bunsen burner. **CAUTION:** *Secure all loose clothing and hair from open flame. Avoid over-boiling. Use Figure 66-1 as a guide.*
- Add four to five drops of acetic acid to each tube. **CAUTION:** *Acetic acid may burn. If spillage occurs, rinse with water and call your teacher immediately.*
- Observe the top portions of both tubes (Figure 66-2). Record in Table 66-1 any changes you observe.

Part D. Phosphate Test

If a urine sample contains phosphate and is heated near the top, a haze will form in the top portion. Acetic acid added to the haze will cause the haze to disappear (particularly near the very top of the liquid). No haze formation in the heated top portion of a urine sample means no phosphate is present.



- Add $\frac{1}{2}$ test tube of urine with phosphates to a test tube.
- Add $\frac{1}{2}$ test tube of urine without phosphates to a second test tube.
- Label the test tubes as to their contents.
- Heat only the top portion of each urine sample over a Bunsen burner.
- Add four to five drops of acetic acid to each tube.
- Observe the top portions of both tubes (Figure 66-2). Record in Table 66-1 any changes you observe.

Part E. Testing an Unknown Urine Sample

- Obtain a sample of urine marked "unknown." It is called an "unknown" because you do not know what is present or absent in this sample.

TABLE 66-2. RESULTS OF UNKNOWN URINE SAMPLE	
TEST	PRESENT OR ABSENT
Glucose	
Chloride	
Albumin	
Phosphate	

- Perform the glucose, chloride, albumin, and phosphate test on the "unknown." Use the proper amount of urine and chemicals needed to run each test. Make sure that all test tubes are clean. Use Parts A through D of the experiment as a guide.
- Record your findings in Table 66-2.

Analysis

1. Define the following terms:

(a) urea _____

(b) glucose _____

(c) chloride _____

(d) albumin _____

2. What chemical not tested for in this experiment makes up the greatest portion of urine? _____

3. (a) Describe how one can tell if glucose is present in a urine sample. _____

(b) Describe how one can tell if chloride is present in a urine sample. _____

(c) Describe how one can tell if albumin is present in a urine sample. _____

(d) Describe how one can tell if phosphate is present in a urine sample. _____

TABLE 66-3. NORMAL COMPOSITION OF URINE AND BLOOD					
	GLUCOSE	ALBUMIN	PHOSPHATE	CHLORIDE	UREA
Urine	not present	not present	present	present	present
Blood	present	present	present	present	present

4. Using Table 66-3, tell which chemicals are normally

(a) present in urine. _____

(b) absent in urine. _____

TABLE 66-4. AMOUNTS OF CHEMICALS IN URINE AND BLOOD (g/100 mL)					
	GLUCOSE	ALBUMIN	PHOSPHATE	CHLORIDE	UREA
Urine	—	—	.16	.5	1.8
Blood	.09	4.0	.004	.35	.03

5. Using Table 66-4, tell which chemical is present in the

(a) least amount in urine. _____

(b) most amount in urine. _____

6. Using Table 66-3, tell which chemicals are normally

(a) present in blood. _____

(b) absent in blood. _____

7. Using Table 66-4, tell which chemicals are present in greater amounts in urine than in blood. _____

8. (a) The kidney can concentrate certain chemicals from the blood and remove them from the body in urine. Using Table 66-4, tell which chemical is concentrated the most by the kidney. (Which

chemical appears to be highest in urine when compared to its amount in blood?) _____

(b) Explain why removal of this chemical is important to the body. (HINT: Reread introduction.) _____

9. (a) Which chemicals usually are not removed from your body as blood is filtered through the kidneys? _____

(b) Why do you think these chemicals usually are retained while other chemicals are filtered from the blood? _____

(c) Why might the presence of these chemicals in urine alert a doctor to some possible medical problem? _____

SKELETAL MUSCLES

67

Every time you move part of your body, the action of muscles is required. Muscles are responsible for moving bones. It is this bone movement that results in your being able to walk, run, lift objects, or even nod your head yes and no. Muscle tissue is able to allow these movements because of its ability to shorten in length.

In this investigation, you will

- (a) examine a slide of skeletal muscle under the microscope.
- (b) compare diagrams of arm and leg muscles to determine how the shortening of muscles results in body movement.
- (c) prepare a muscle model to demonstrate the way that muscle shortening results in body movement.

Materials

microscope
prepared slide of skeletal muscle
string (2 pieces, each 20 cm long)

poster board
paper punch
metal fastener

metric ruler
scissors

Procedure

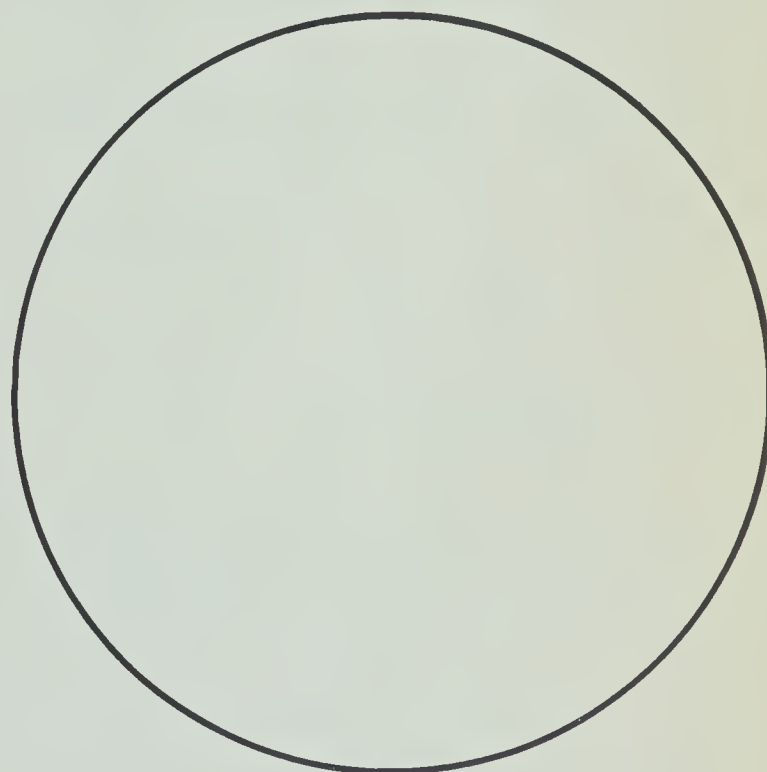
Part A. Skeletal Muscle, Microscopic View

Skeletal muscle is attached to your skeleton. It makes up the bulk of your body weight.

- Examine a prepared slide of skeletal muscle under the microscope. Use low and high powers.
- Note the many nuclei (dark, round bodies) present. Also note that muscle tissue is made up of long strands or fibers. Each fiber shows a striped pattern resulting from alternating bands of light and dark protein fibers.
- Diagram skeletal muscle under high power in the space provided. Label *muscle fiber* and *nucleus*.

Part B. Muscle Contraction and Body Movement

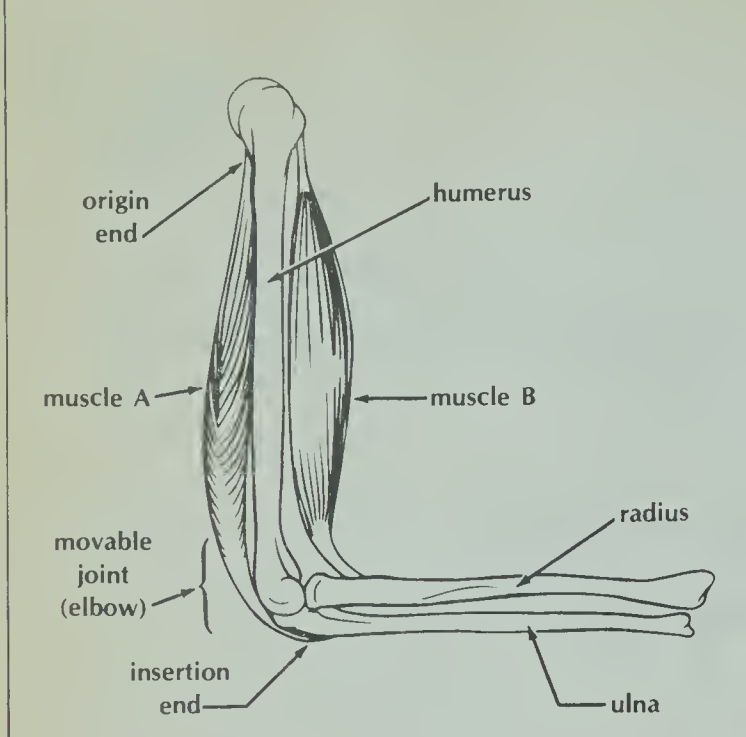
Skeletal muscle does its job of moving bones or body parts by shortening its length. Biologists call this shortening contraction. As muscle contracts, it pulls bones or body parts into different positions. The muscles are attached to bones at



skeletal muscle

two different places. During contraction, one end of the muscle and what it is attached to do not move. The other end of the muscle and what it is attached to move when the muscle contracts. When not contracting, muscle is said to be relaxing.

FIGURE 67-1



● Examine Figure 67-1. It shows how the muscles of your upper arm are attached to your lower arm. The top end of one muscle (marked A) is attached to the middle of a nonmovable portion of the upper arm bone (humerus). This muscle end is called the point of origin. The muscle stretches over the elbow and is attached to the end of the lower arm bone (ulna). This muscle end is called the point of insertion. As the muscle shortens or contracts, the ulna is pulled down.

Figure 67-2 shows how the arm looks as muscle A contracts. Note that as a skeletal muscle shortens, it tends to bulge out.

Figure 67-3 shows a second arm muscle marked B.

● Label its point of origin.

● Label its point of insertion.

● Use Figure 67-3 to predict the location of the lower arm when muscle B contracts. Complete the diagram by drawing over the proper dashed lines to correctly show the new lower arm position.

1. How does muscle B change in shape as it contracts?_____

2. (a) Measure the length of muscle B in Figure 67-2. Record its length in millimetres here._____

(b) Measure the length of muscle B in Figure 67-3. Record its length in millimetres here._____

FIGURE 67-2

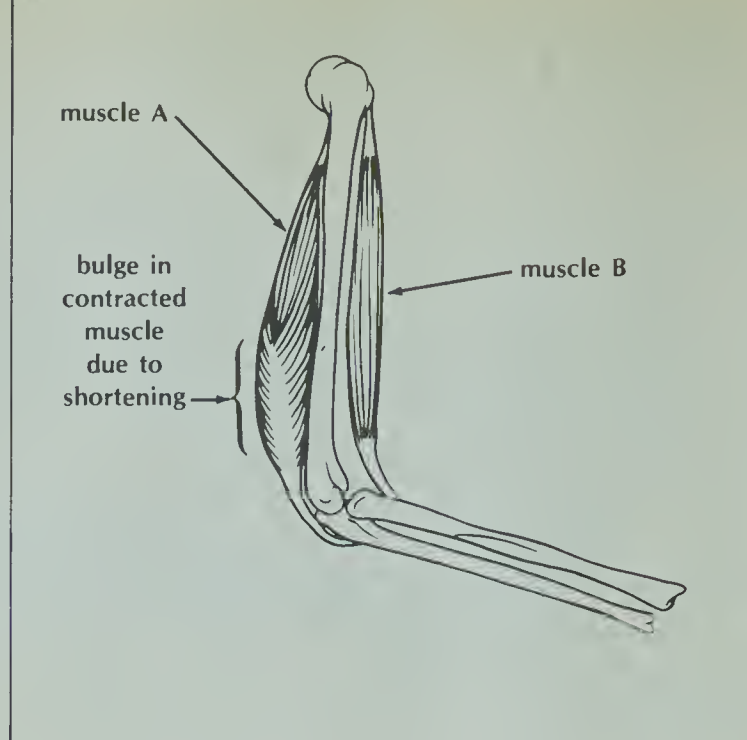
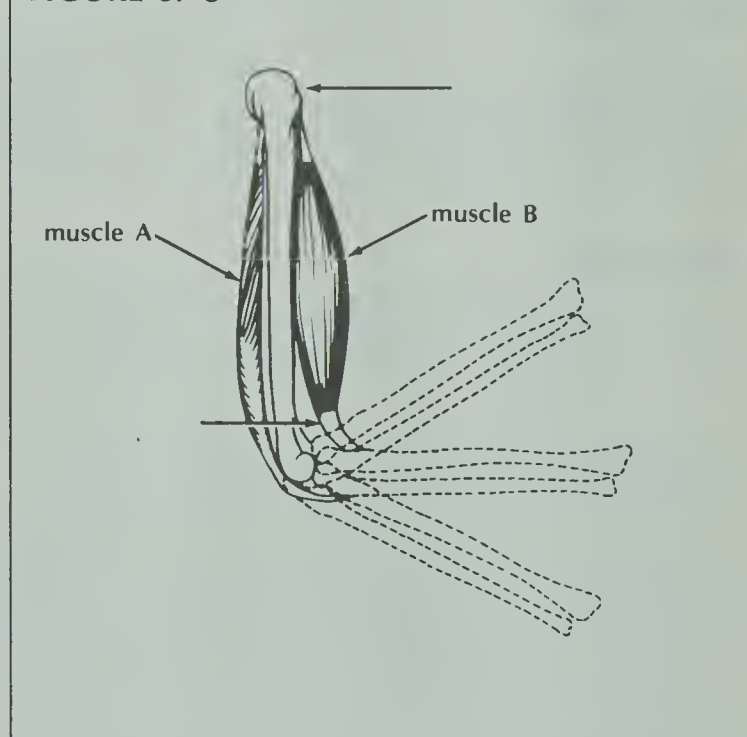


FIGURE 67-3



- (c) How did the length of muscle B change as it contracted?_____
3. (a) Does muscle A move the lower arm up or down?_____
- (b) Does muscle B move the lower arm up or down?_____
- (c) How many different muscles are needed to move the lower arm up and down?_____

● Figure 67-4 shows one of the muscles needed to move your foot down. The muscle, however, is

FIGURE 67-4



shown with only dashed lines. Label the *points of origin* and *insertion* of the muscle. Remember, the ankle is a movable joint.

- Complete Figure 67-4 by drawing over the correct muscle shape when the foot is pulled down.

- Figure 67-5 shows one of the muscles needed to move your foot up. The muscle again is shown with dashed lines. Complete Figure 67-5 by drawing over the correct muscle shape when the foot is pulled up. Label the *points of origin* and *insertion* of this muscle.

4. (a) In Figure 67-4, is movement of the foot down achieved when the muscle shown

contracts or relaxes? _____

(b) In Figure 67-5, is movement of the foot up achieved when the muscle shown contracts

or relaxes? _____

5. (a) Can the same muscle move your foot both

up and down? _____

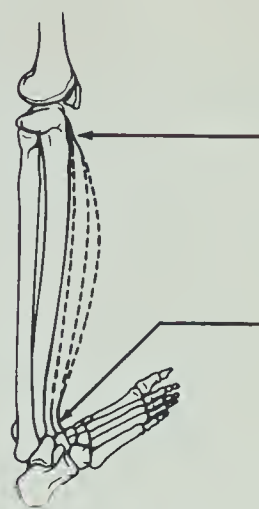
(b) How many different muscles does it appear to take to accomplish movement up and

down? _____

Part C. Muscle Model

Scientists often use models to help illustrate a particular idea or concept. This part of the investigation will use a muscle-skeleton model to help illustrate the concepts from Part B.

FIGURE 67-5



- Trace Figure 67-6 onto a piece of paper.

- Cut out your traced figures and use them as a pattern for outlining the figures onto heavy paper (posterboard). **CAUTION:** Always be careful with scissors.

- Cut out the figures and connect both model pieces by using a metal fastener.

- Push the fastener through at the points marked with an X.

- Punch holes where indicated on both pieces.

FIGURE 67-6

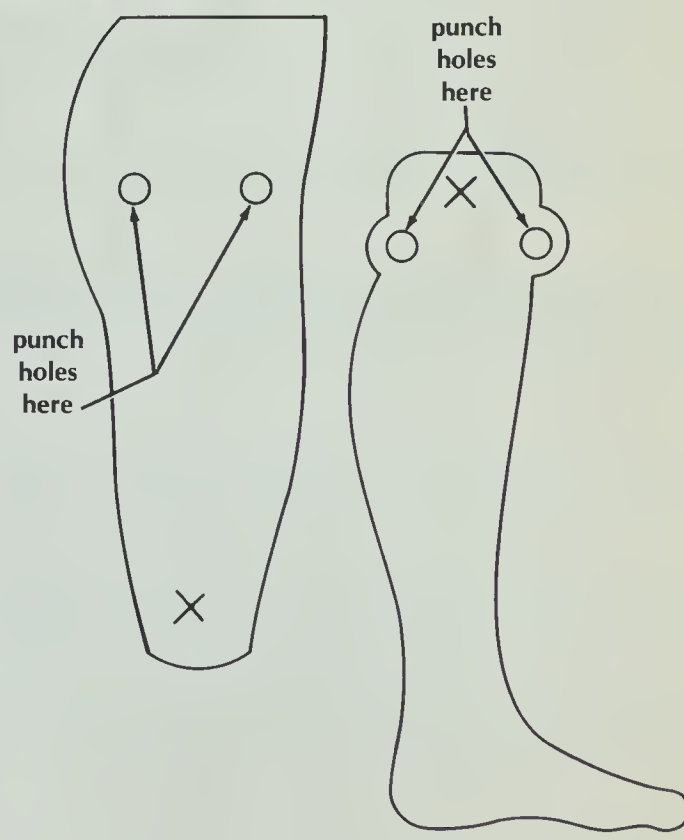


FIGURE 67-7

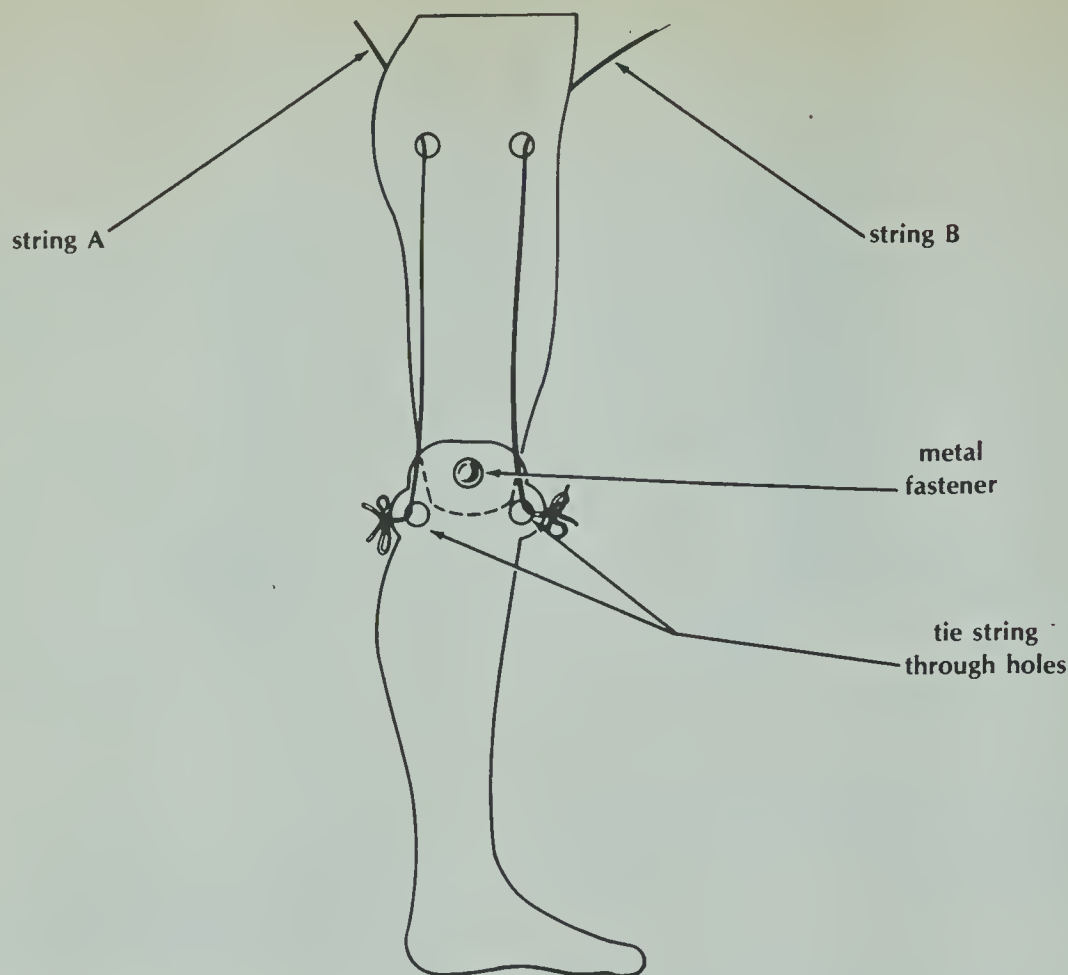


TABLE 67-1. MUSCLE MODEL SUMMARY

LEG POSITION	STRING TO BE PULLED?	LENGTH OF STRING IN MILLIMETRES		MUSCLE (STRING) RELAXED OR CONTRACTING?	
		A	B	A	B
Straight					
Pulled forward					
Pulled backward					

- Add string to your model as shown in Figure 67-7. The strings represent the muscles present in your thigh.

- Position your leg model so that the foot appears flat as if the leg were standing on a flat surface.

- Measure the length of each string in millimetres and record these numbers in Table 67-1. NOTE: Measure only from where the string is tied in place to where it enters the top hole. Refer to the string on the left side as string A and the one on the right side as string B.

- Determine which string must be pulled in order to move the leg forward. Remeasure the strings while the leg is forward and record their lengths in the proper row of Table 67-1.

- Determine which string must be pulled in order to move the leg backward. Remeasure the strings while the leg is pulled back and record their lengths in the proper row of Table 67-1.

- Complete the last two columns of Table 67-1.

Analysis

1. Define the following terms:

(a) skeletal muscle _____

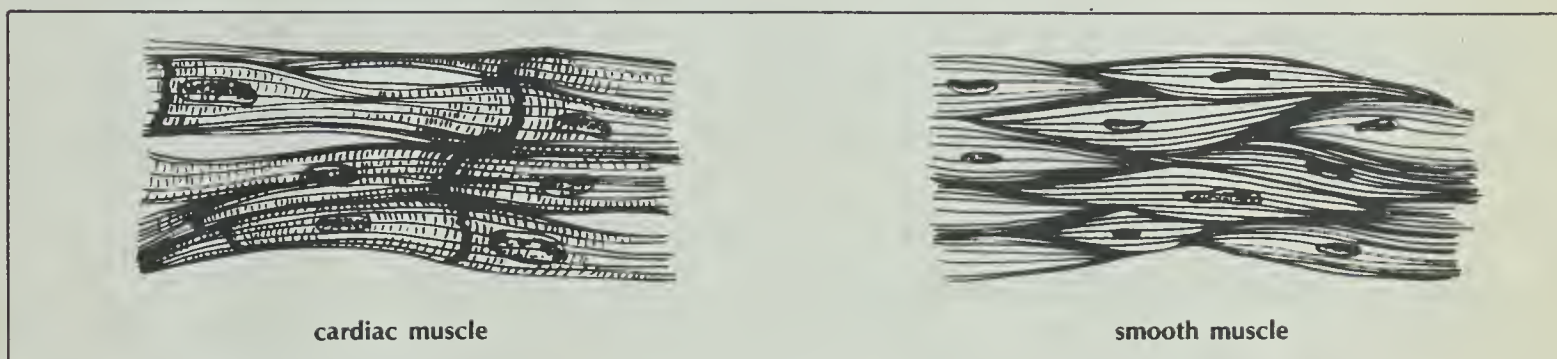
(b) contraction _____

(c) point of origin _____

(d) point of insertion _____

2. In Part A, you examined skeletal muscle. It is sometimes called striated muscle. Why is this name appropriate? _____

3. These two diagrams show two other muscle types present in your body. They are both drawn as they would appear under high power magnification.



(a) Use your text or other resources to determine where in your body cardiac and smooth muscle are found. _____

(b) Explain how cardiac muscle fibers differ from the fibers of skeletal muscle. _____

(c) Explain how smooth muscle differs from skeletal and cardiac muscle when comparing appearance of stripes. _____

4. Skeletal muscles are always found in pairs in your body. That is, one muscle moves a body part in one direction and a different muscle moves the same body part in an opposite direction. This pairing is referred to as antagonistic pairs.

(a) What is the meaning of the word antagonist? _____

(b) Were muscles A and B in Figures 67-1 and 67-3 antagonistic pairs? _____

Why? _____

- (c) Were the two muscles in Figures 67-4 and 67-5 an antagonistic pair?_____
- Why?_____
5. Using Figures 67-1 and 67-3 again, describe the condition (contracted or relaxed) for:
- (a) muscle A in 67-1_____
- muscle B in 67-1_____
- (b) muscle A in 67-3_____
- muscle B in 67-3_____
- (c) Describe how antagonistic muscles behave when a body part is moved in one direction and then in the opposite direction._____
- _____
6. Using your model from Part C,
- (a) explain what the two strings represent._____
- _____
- (b) explain what the metal fastener represents._____
- _____
- (c) explain the relationship between the two strings. (Were they antagonistic?)_____
- _____
- (d) explain what pulling on each string actually represents._____
- _____
7. Using your model from Part C,
- (a) describe where the points of origin of those muscles which move your leg are located._____
- _____
- (b) describe where the points of insertion of those muscles which move your leg are located._____
- _____
8. (a) In designing a marionette (puppet), how many strings would be needed to allow it to nod its head "no"?_____
- turn its body toward the left or right?_____
- (b) Could these strings be thought of as antagonistic muscles?_____
- Explain._____
- _____

MEASURING DIFFERENCES IN MUSCULAR ACTIVITY

68

While performing various activities, muscles in your body contract. Muscle contraction requires energy. This energy is obtained through cell respiration. During respiration, carbon dioxide is released as a waste product. Carbon dioxide is carried by the blood to the lungs where it is exhaled.

Would an increase in muscular activity, such as running, create an increased energy demand on muscles? If an increased energy demand occurs, would there be a corresponding increase in the amount of carbon dioxide produced and then exhaled? These two questions will be answered in this investigation.

When carbon dioxide is added to a solution of bromthymol blue, it turns green (bromthymol green). The amount of carbon dioxide in the bromthymol green can be determined by a technique called titration. Adding sodium hydroxide to bromthymol green will change the color back to blue (bromthymol blue).

The number of drops of sodium hydroxide needed to restore the original color is a measure of the carbon dioxide added. For example, if only a little carbon dioxide is added to bromthymol blue, only a few drops of sodium hydroxide are needed to restore the original color. If much carbon dioxide is added to bromthymol blue, many drops of sodium hydroxide are needed.

In this investigation, you will

- (a) describe how carbon dioxide alters the color of bromthymol blue.
- (b) use a titration technique to measure the amount of carbon dioxide added to bromthymol blue.
- (c) compare the amounts of carbon dioxide produced by muscle tissue during different activities.
- (d) explain how carbon dioxide production can be used to compare differences in muscular activity.

Materials

small flasks—2
bromthymol blue solution
sodium hydroxide (0.4% solution)
dropper
drinking straws—6
water

test tubes—2
1 hole stopper to fit test tube
glass tube—3 cm long
rubber tube—3 cm long
½ effervescent tablet
graduated cylinder

Procedure

Part A. Changing Bromthymol Blue Color with Carbon Dioxide Gas

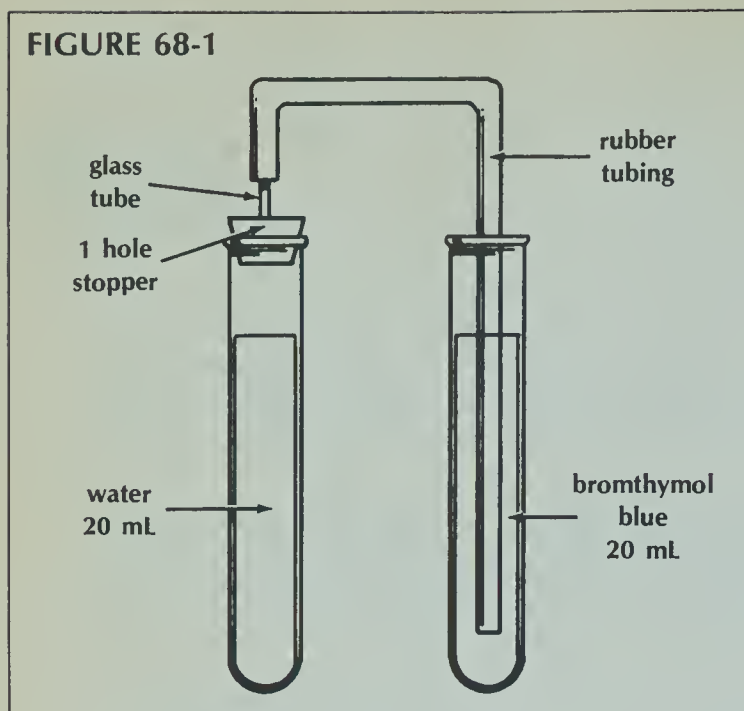
- Assemble the apparatus as shown in Figure 68-1.

- Remove the stopper from the test tube. Drop half an effervescent tablet into the water. Quickly restopper the test tube.

- Note the series of color changes in the bromthymol blue solution as the gas produced in the stoppered tube bubbles into the solution.

When added to water, effervescent tablets form carbon dioxide gas. The bubbles escaping from the rubber tubing are carbon dioxide gas.

FIGURE 68-1



1. What color is bromthymol blue before carbon dioxide gas is added to it? _____
2. How does the color of bromthymol blue change as carbon dioxide gas is added? _____
3. Explain how bromthymol blue can be used as a means of detecting carbon dioxide gas. _____

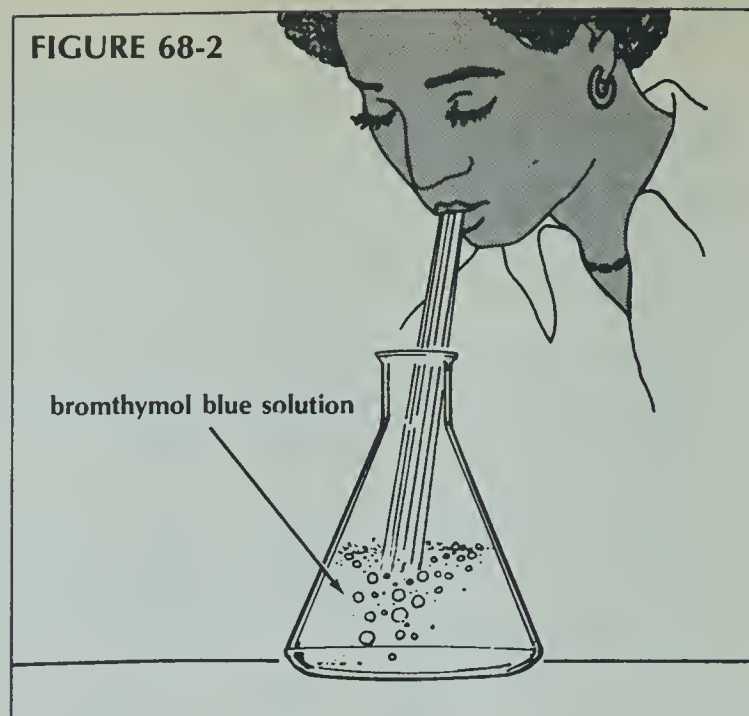
Part B. Amount of CO₂ Exhaled After Quiet Muscular Activity—Sitting

- Add 100 mL of bromthymol blue solution to each of two flasks.
- Place six straws into one of the flasks.
- Breathing normally, breathe in through your nose but exhale through the straws into the bromthymol blue solution. Continue breathing and exhaling. **CAUTION:** *Be careful not to suck the solution into your mouth.* Use Figure 68-2 as a guide. **DO NOT** force your breathing; exhale normally. Be sure that all exhaled breath goes through the straws.

The solution should change from blue to a pale green.

- Remove the straws from the flask.
- With a dropper, add a drop of sodium hydroxide solution to the flask. **CAUTION:** *Do not get*

FIGURE 68-2



sodium hydroxide on skin or clothing. If you do, rinse with water and call your teacher.

- Swirl the flask to mix the contents.
- After at least ten seconds, add another drop of sodium hydroxide to the flask. Again, swirl the flask and wait ten seconds.
- Continue to add and count the number of drops of sodium hydroxide needed to return the liquid to its original blue color. Swirl and wait ten seconds after the addition of each drop. Use the color of the solution in the second flask as a guide to the original color.
- Record in Table 68-1 the number of drops of sodium hydroxide needed. Use the column marked Trial 1/Sitting.
- Pour the contents of both flasks into one of the flasks.
- Refill the empty flask with half of the bromthymol blue solution.
- Repeat the entire experiment in Part B three more times. Remember to:
 - (a) count the number of drops of sodium hydroxide used in each trial.
 - (b) mix the liquids together after each trial.
 - (c) record your results in the proper row and column of Table 68-1.
- Determine the average number of drops of sodium hydroxide needed in the four trials.
- Record the average in Table 68-1.

Part C. Amount of CO₂ Exhaled After Strenuous Muscular Activity—Running

● Add 100 mL of bromthymol blue solution to each of two flasks.

● Run in place for exactly one minute.

● Exhale through the six straws into a flask of bromthymol blue solution for exactly one minute. Make sure that as much exhaled air as possible is directed through the straws; not around the straws or through your nose.

● Following the technique of Part B, add drops of sodium hydroxide to the flask until the blue color is restored.

● Count and record in Table 68-1 the number of drops needed to restore the blue color. (Use the other flask for a color comparison.)

● Repeat Part C three times. Run in place for one minute before starting each trial. Remember to:

TABLE 68-1. DROPS OF SODIUM HYDROXIDE USED

	SITTING	RUNNING
Trial 1		
Trial 2		
Trial 3		
Trial 4		
Total		
Average		

(a) count the number of drops of sodium hydroxide used in each trial.

(b) mix the liquids together after each trial.

(c) record your results in Table 68-1.

● Record and average all data in Table 68-1.

Analysis

1. Using the averages for your data, which condition, sitting or running, required more drops of sodium hydroxide to return the bromthymol to the original blue color?_____

2. The number of drops of sodium hydroxide needed to turn bromthymol green to bromthymol blue indicates the amount of CO₂ added to the flask during exhaling. Use your average data to explain which condition, sitting or running, produced more carbon dioxide._____

3. Does the average for your data agree exactly with the averages recorded by other students

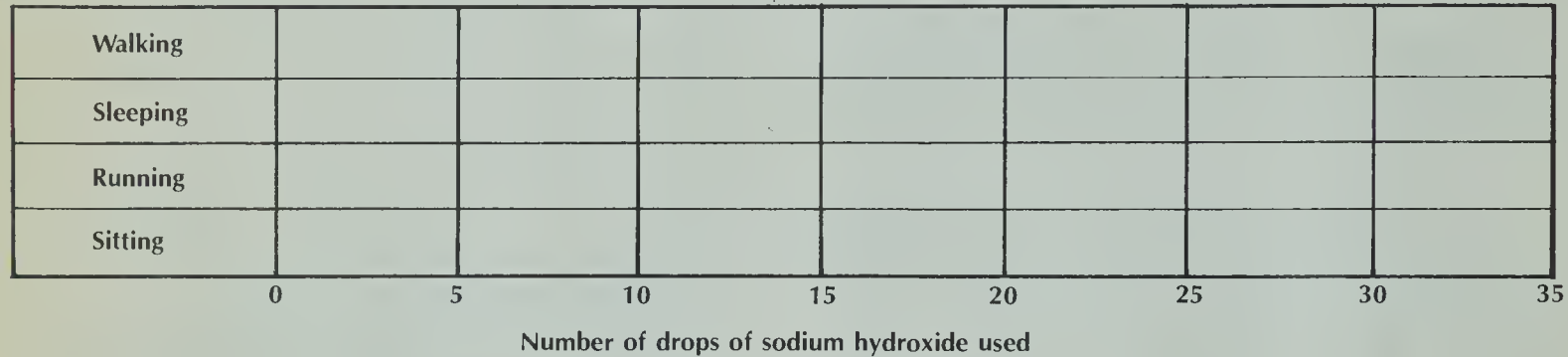
(a) in Part A?_____

(b) in Part B?_____

(c) Why or why not?_____

4. Explain how muscular activity influences the amount of carbon dioxide being released.
- _____
- _____
- _____
- _____
5. Using Figure 68-3, prepare a bar graph of your data. (a) Shade in horizontal bars which correspond to the results obtained for your average sitting and running values. (b) Shade in bars which illustrate the experimental data you might expect if the experiment were performed while sleeping and walking.

FIGURE 68-3



6. In terms of energy requirements, explain your bar graph values for walking and sleeping.
- _____
- _____
- _____
- _____
7. Experimental results can be described qualitatively and quantitatively. Qualitative results are a general description of the results usually in words. Quantitative results are a specific description of amounts involved using numbers.
- (a) Which part of this investigation was qualitative?_____
- (b) Why?_____
- _____
- _____
- (c) Which part of this investigation was quantitative?_____
- (d) Why?_____
- _____
- _____

THE THYROID GLAND

69

The thyroid gland is one of the endocrine glands present in the human body. It produces a hormone called thyroxine. Thyroxine controls the metabolic rate of body cells. The amount of thyroxine produced by your thyroid depends on and is controlled by the amounts of two other hormones present in the body. Thyrotropin-releasing factor (TRF) is produced by an area of the brain called the hypothalamus. Thyroid-stimulating hormone (TSH) is a hormone made by the pituitary gland. These three chemicals interact in maintaining a suitable thyroxine level.

In this investigation, you will

- label drawings showing location of the body parts involved in thyroxine regulation and the hormones produced.
- complete drawings showing inhibitory and stimulatory effects.
- observe thyroid tissue under the microscope.

Materials

microscope
prepared slide of normal thyroid gland
prepared slide of thyroid gland with goiter

Procedure

Part A. Identifying Glands and Hormones Related to Thyroid Action

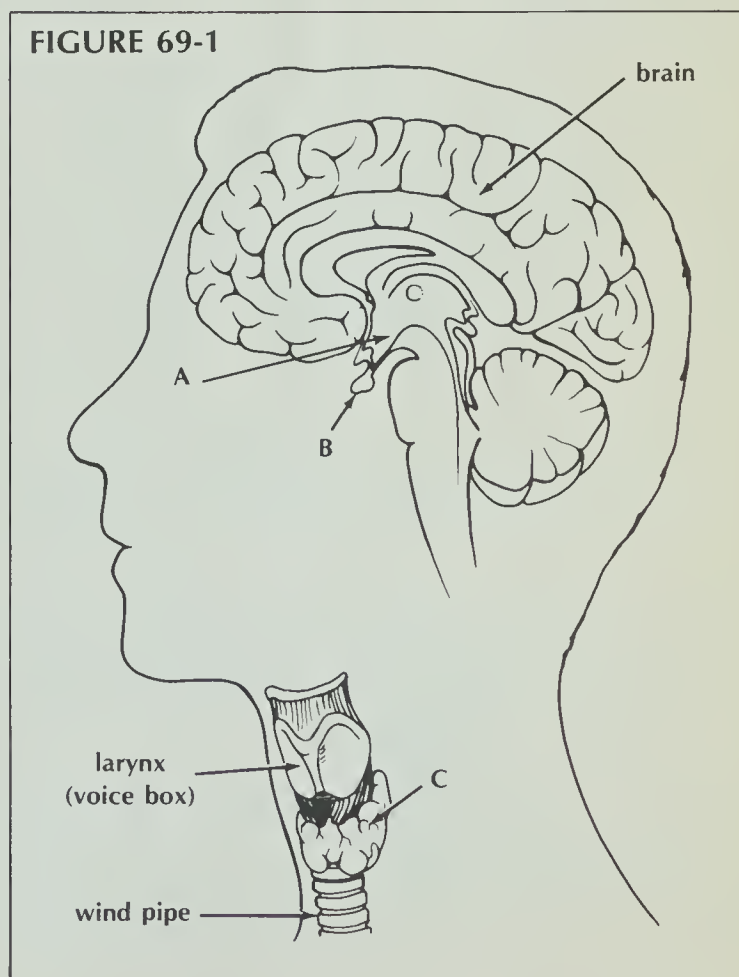
- Look at Figure 69-1. Letter A shows the location of the hypothalamus. Letter B shows the location of the pituitary gland. Letter C shows the location of the thyroid gland.

The hormones produced by these three glands interact in the following manner to maintain the correct thyroxine level. TRF from the hypothalamus stimulates the pituitary gland to form and release TSH. TSH stimulates the thyroid to form and release thyroxine. Thyroxine in turn influences the production of TRF.

- Draw arrows on Figure 69-1 to indicate these three hormones. The arrow should point from the producing gland to the influenced gland.

- Label each arrow with the name of the hormone it represents.

FIGURE 69-1

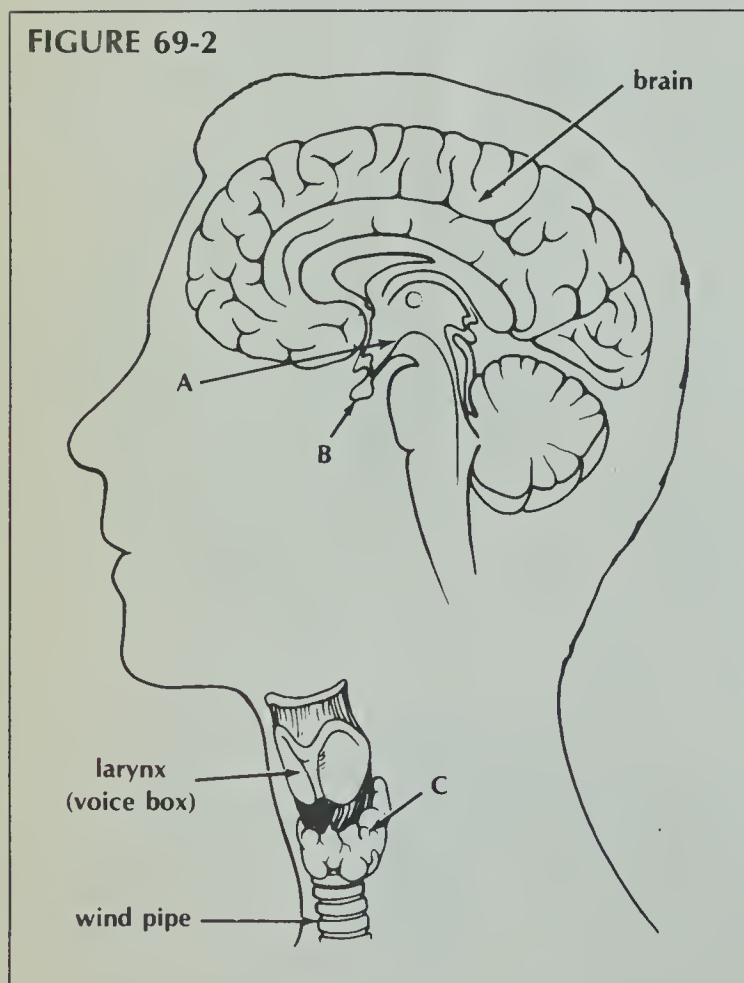


Part B. Inhibitory and Stimulatory Effects of These Hormones

The release of the correct amount of thyroxine in your body is regulated by a constant "turning on and off" of the thyroid gland. This "on" and "off" action of the thyroid is self-regulating. As the amount of thyroxine increases in your body, it causes the hypothalamus to slow its production of TRF. This "turning off" of the hypothalamus causes an inhibitory effect on the production of thyroxine.

1. What hormone is no longer produced by the hypothalamus when it is "turned off"? _____
2. If TRF is no longer produced, what happens to the production of TSH? _____
3. What happens to thyroxine production when TSH stops? _____

● Use Figure 69-2 to show the events that lead to the inhibition of thyroxine production. Use arrows of different widths to indicate the amounts of each hormone present when the hypothalamus is "turned off." HINT: Remember, thyroxine production must be high in order to trigger the inhibitory effect.



● Label the arrows with the names of the hormones and each hormone's relative amount. Use the words *increases* and *decreases*.

As the amount of thyroxine decreases in your body due to the events just described, the hypothalamus resumes its production of TRF. This "turning on" of the hypothalamus results in a stimulatory effect on the production of thyroxine.

4. What hormone is again produced if the hypothalamus is "turned on"? _____
5. What happens to the pituitary when the hypothalamus is "turned on"? _____
6. What happens to thyroxine production when TSH production begins again? _____

● Use Figure 69-3 to show the events that lead to increased thyroxine production. Use arrows of different widths to indicate the amounts of each hormone present when the hypothalamus "turns on." HINT: Remember, thyroxine production must be low in order to trigger the stimulatory effect.

● Label the arrows with the names of the hormones and each hormone's relative amount. Use the words *increases* and *decreases*.

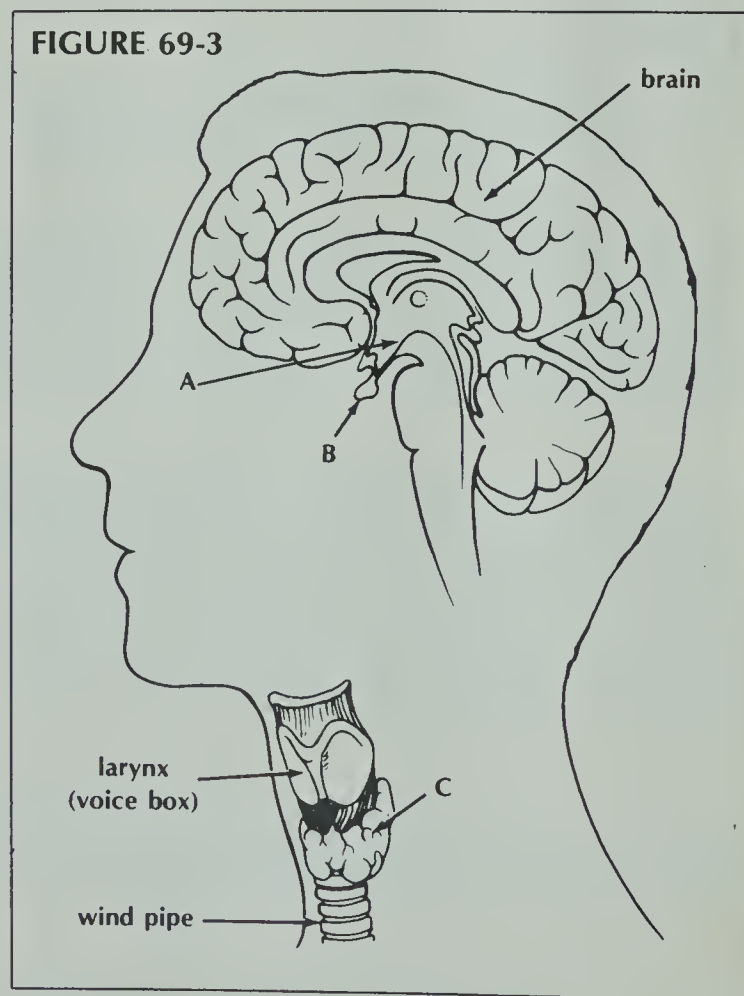


FIGURE 69-4

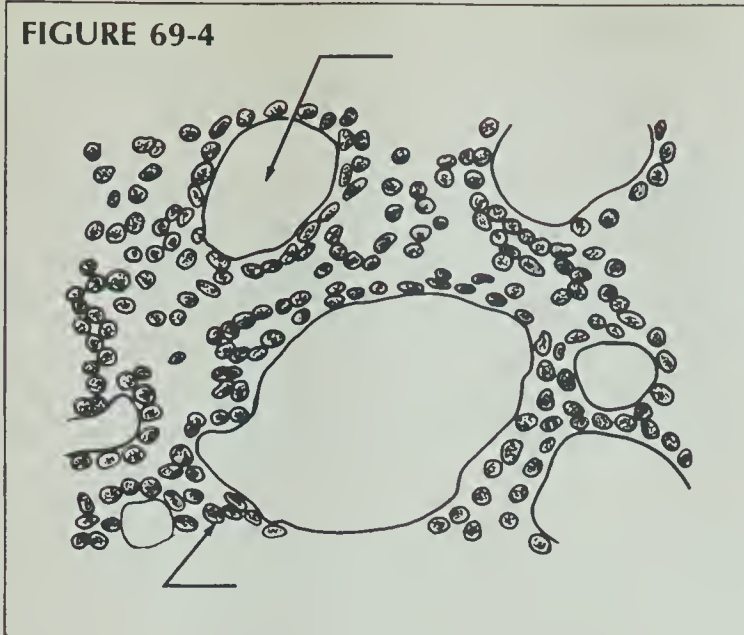
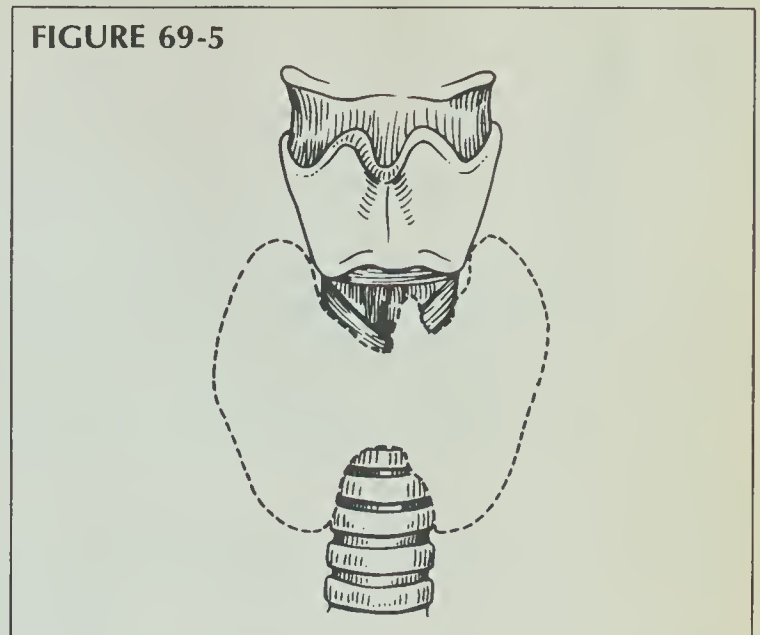


FIGURE 69-5



Part C. Observing Thyroid Tissue

- Examine a prepared slide of the thyroid under low power.
- Identify and label the following areas on Figure 69-4:
 - (a) *colloid*—noncellular, liquid areas of thyroid.
 - (b) *follicle*—areas or patches in thyroid that surround colloid; no specific shape or size.

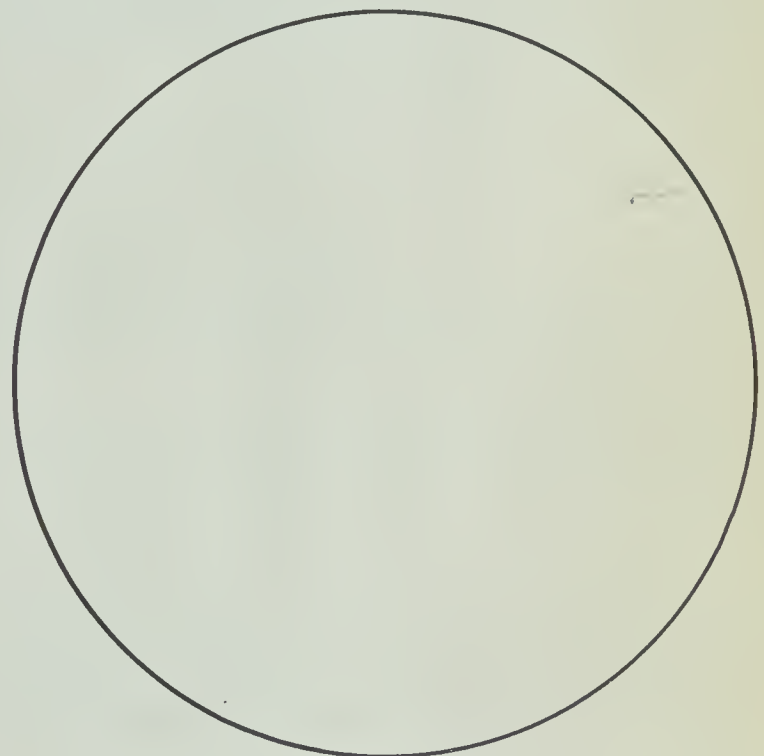
Part D. Abnormal Thyroid Functioning

Iodine is an important part of thyroxine. Iodine must be present in order for thyroxine to form. The iodine is supplied to the body by food. Lack of iodine results in thyroxine deficiency.

7. If the amount of thyroxine is reduced, which figure, Figure 69-2 or 69-3, would show the results that take place? _____

8. Explain. _____

A supply of TRH and TSH with no inhibitor causes the thyroid gland to enlarge. Recall from Part B that TSH stimulates the thyroid to produce more thyroxine. TSH continues to stimulate the thyroid, but no thyroxine is formed. This constant stimulation results in an increase in the size of the colloid areas of the gland. This condition is called a goiter.



thyroid tissue
affected by goiter

- Under low power, examine a prepared slide of a thyroid gland affected with goiter.
- Diagram the appearance of the affected tissue in the space provided. Label *colloid* and *follicle*.
- Diagram on Figure 69-5 what the shape of a thyroid affected with goiter might look like. NOTE: The normal outline of the thyroid is represented by dashed lines.

Analysis

1. Name one hormone studied in this investigation produced by your

(a) hypothalamus. _____

(b) pituitary gland. _____

(c) thyroid gland. _____

2. Define the following terms:

(a) inhibitory effect _____

(b) stimulatory effect _____

(c) self-regulating _____

(d) goiter _____

3. (a) Increased amounts of thyroxine can turn off the supply of thyroxine. Explain briefly how this inhibitory effect occurs. _____

(b) Decreased amounts of thyroxine can turn on the supply of thyroxine. Explain briefly how this stimulatory effect occurs. _____

4. What role does thyroxine play in the human body? (HINT: Reread introduction.) _____

5. Many people in the U.S. during the last century developed goiters. They lived primarily in the central part of the country away from the ocean coasts. Explain why goiters may have developed in these areas.

(NOTE: People along the oceans ate more seafood which contains iodine.) _____

6. Today, table salt is iodized, meaning that it has iodine added to it. Why is addition of iodine to salt a healthful practice, especially for those who do not eat seafood? _____

INSECT METAMORPHOSIS

70

The endocrine system is composed of several ductless glands. These glands produce chemicals called hormones. Hormones chemically control many changes within the bodies of organisms. Metamorphosis is one life process which is controlled by hormones. Metamorphosis means to change (meta) form (morphosis). The butterfly is one type of animal which undergoes complete metamorphosis. Complete metamorphosis consists of four different stages—egg, larva, pupa, and adult.

In this investigation, you will

- (a) examine preserved material of three stages of a Monarch butterfly's life cycle.
- (b) label the stages of this life cycle on a diagram.
- (c) identify the hormones that control the process of molting and metamorphosis in the butterfly's life cycle and describe how these hormones interact.

Materials

larva, pupa, adult stages of *Danaus archippus* (Monarch butterfly), preserved
hand lens or binocular scope

Procedure

Part A. Butterfly Life Cycle

- Examine the preserved larva with a hand lens or binocular scope. Look for body segments, mouthparts, antennae, legs, and wings.

Larvae develop from fertilized eggs. Often called caterpillars, larvae can often be found feeding on plant leaves and other organic material. In many species, the larval stage is the only one in which the insect eats. Monarch butterflies, however, do ingest food as adults.

- Examine several of your classmates' larva specimens. Note the different sizes of larvae.

The larval stage is a period of rapid growth in the insect's life cycle. Periodically during this stage, the larva sheds its skin. This process, called molting, is under hormonal control and allows the larva to grow in size.

- Label *larvae* on Figure 70-1.

1. Why are two larvae of different sizes shown in

Figure 70-1? _____

2. What process has occurred in order for the larvae to grow? _____

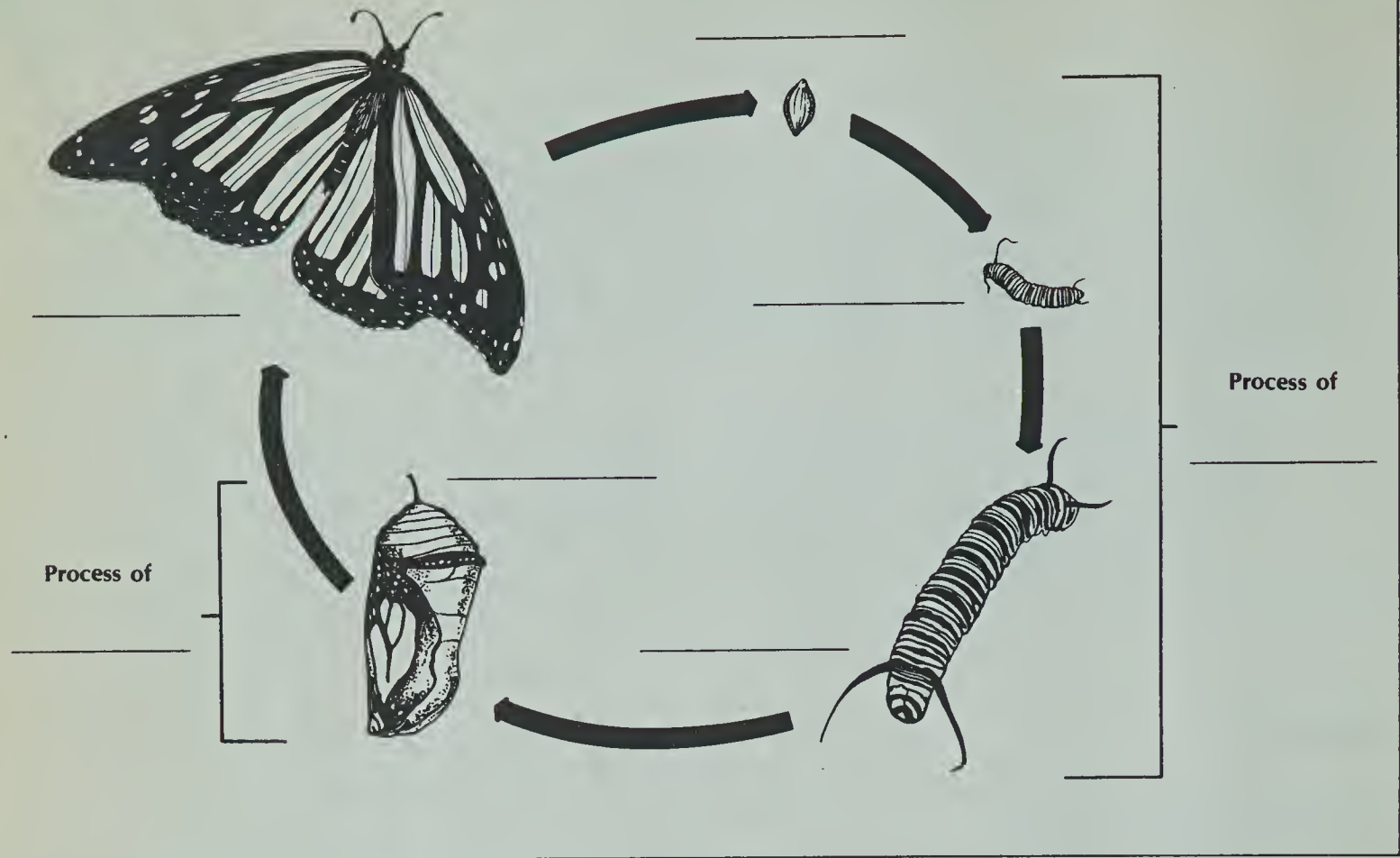
- Examine the preserved pupa with a binocular scope or hand lens.

After the larva finishes its growth period and series of molts, it becomes inactive and changes to a pupa. The pupa is usually enclosed within a protective shell or case. In nature, the pupa hangs by the tip of the abdomen which is fastened to a plate of silk spun by the larva. During this stage, no feeding occurs, but all the tissues of the animal are completely reorganized. This reorganization is the process of metamorphosis.

As the larva metamorphosizes into an adult, the protective case which encloses it "clears," or becomes transparent.

- Examine several of your classmate's preserved pupae. Note that the adult butterfly can be seen through the case of "older" pupae.

FIGURE 70-1



- Label *pupa* on Figure 70-1.
- Examine the preserved adult butterfly with a binocular scope or hand lens.

Adults emerge from the pupa after the process of metamorphosis described above occurs. The adult Monarch butterfly is the only butterfly species known to perform an annual two-way migration. In a two-way migration, the same individual flies south, hibernates, and then flies north in the spring to mate and lay eggs. To attract females, males have a patch of scent scales on a vein just below the center of each hind wing. These scales look like a dark swelling on the vein.

- Locate the scent scales on your butterfly (or a classmate's butterfly, if your specimen is not a male.)
- Label *adult* on Figure 70-1.

3. What process has occurred to change the pupa to an adult? _____

- Label on Figure 70-1 where the processes of *molting* and *metamorphosis* occur.
- Complete Table 70-1 summarizing the Monarch butterfly life cycle. Use check marks where appropriate in the table.

TABLE 70-1. MONARCH BUTTERFLY LIFE CYCLE							
	QUIET, NON-FEEDING STAGE	STAGE SHOWS EVIDENCE OF BODY SEGMENTS	ANTENNAE PRESENT	FEEDING STAGE	WINGS PRESENT	MOUTH PARTS VISIBLE	UNDERGOES MOLTING
Larva							
Pupa							
Adult							

Part B. Hormone Control of Life Cycle

The normal life cycle pictured in Figure 70-1 is under hormonal control. Three main hormones interact to bring about molting and metamorphosis. Two hormones, thoracotropin and juvenile hormone, are formed by glands or areas within the insect's brain. The third hormone, ecdyson, is formed by glands located in the thorax.

These three hormones interact in the following way.

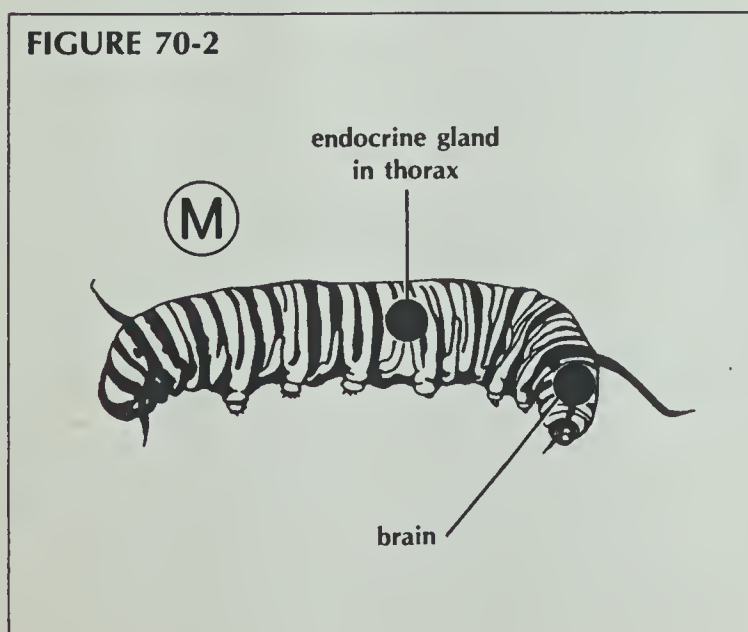
- Thoracotropin stimulates glands in the thorax to produce ecdyson.
- Ecdyson causes the larva to undergo molting.
- Juvenile hormone prevents the larva from undergoing metamorphosis and works with ecdyson to cause molting. (A juvenile butterfly is a larva.)

As long as ecdyson and juvenile hormone are both present, the insect continues molting and growing.

● Use Figure 70-2 to show the interaction of these three hormones. Use a solid arrow to indicate the action of thoracotropin. The arrow should start where thoracotropin is produced and point to the area which the hormone affects. Label the line *thoracotropin*.

4. What occurs when ecdyson is produced in a juvenile? _____

● Use dotted arrows (--->) on Figure 70-2 to indicate the actions of juvenile hormone and ecdyson. (M) represents molting taking place. Label each line with the name of the hormone it represents.



5. How does juvenile hormone function in a juvenile? _____

If the amount of juvenile hormone drops below a certain level, or stops altogether, the larva stops molting and changes into the pupa.

Part C. Predicting Experimental Results

It is possible to remove sections of insect larvae and still have the sections remain alive. It is also possible to join sections from different larvae together. Hormones produced or present in one larva can pass from one to the other.

6. Explain the results that might be expected in the following experiments.

- A large (mature) larva was about to enter its pupa stage. It was joined to a very young larva. Predict what will happen to the mature larva and explain your prediction.

- A very young larva has its brain removed. Predict what will happen to the larva and explain your prediction.

- A young larva has only the brain portion producing juvenile hormone removed. Predict what will happen to the larva and explain your prediction.

Analysis

1. Define the following:

(a) endocrine gland_____

(b) hormone_____

(c) molting

(d) metamorphosis_____

2. (a) Describe the normal life cycle of a butterfly by writing in the correct stages in their proper sequence.

Egg A \rightarrow B \rightarrow C

- (b) Three arrows above are marked A, B, and C. Indicate below if the process occurring at these three arrows is metamorphosis or molting.

A: _____ B: _____

C: _____

3. (a) Thoraco means "thorax" and tropin means "to turn on." Explain why one brain hormone was named "thoracotropin." _____

- (b) Explain why juvenile hormone is properly named. _____

- (c) Explain why ecdyson is called the molting hormone. _____

4. Name the body region where each of the following hormones is produced.

(a) thoracotropin _____

(b) juvenile hormone_____

(c) molting hormone_____

5. (a) Which two hormones act together to bring about molting? _____

- (b) Which hormone brings about pupa formation if juvenile hormone is not present?_____

(c) Which hormone prevents pupa formation?_____

6. A moth larva has its thorax gland removed. Can it change into a pupa?_____

Explain. _____

THE EYE

71

Sense organs constantly monitor the outside environment, detect stimuli, and send messages to other parts of the nervous system about changes that take place. Sense organs are associated either directly or indirectly by nerves to the brain. The brain does the final interpreting of the messages sent by the sense organs. The eye is one sense organ which detects stimuli in the environment and sends impulses to the brain for interpretation.

In this investigation, you will

- examine the outside of a cow's eye.
- dissect a cow's eye to learn the structures found in the interior of the eye.
- use a diagram to determine how nerve messages are carried from eye to brain.

Materials

preserved cow eye
dissecting pan
tweezers

scissors
razor blade, single edged

Procedure

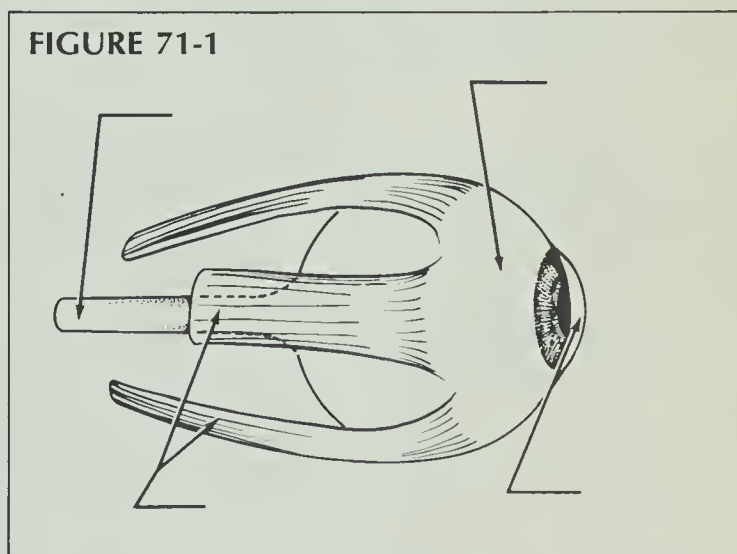
Part A. External Eye Parts

- Examine a preserved cow's eye. Locate the parts listed in Table 71-1.

Complete Figure 71-1 showing a side view of the human eye. Use the labels from Table 71-1. NOTE: Fat has not been included in this diagram.

TABLE 71-1. EXTERIOR EYE STRUCTURES	
PART	LOCATION AND DESCRIPTION
Eye muscles	along top, bottom, and sides of eye; thick, tough bands of pink tissue.
Fat	yellow; surrounds back of eye; may cover some muscles.
Optic nerve	at very back of eye; pink, may be surrounded by fat and muscle, as thick as a pencil.
Sclera	tough, white outer covering of eye; most easily seen at front of eye.
Cornea	clear (or cloudy) covering at front of eye; continuation of sclera.

FIGURE 71-1



Part B. Internal Eye Parts

- Using tweezers and scissors, remove as much of the fat and muscle from the eye as possible. **CAUTION:** Always be careful when using scissors. Do not remove the optic nerve.

- Try pulling some of the eye muscle away from the sclera.

1. Can the muscle be easily removed from the eye? _____

FIGURE 71-2

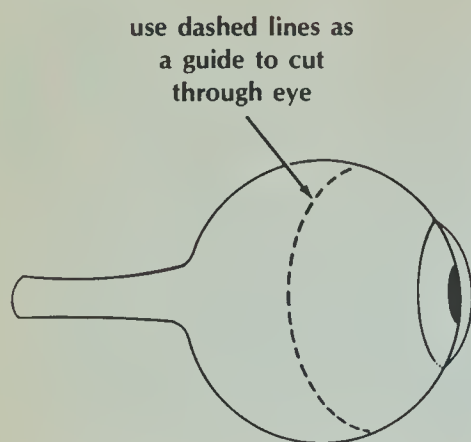
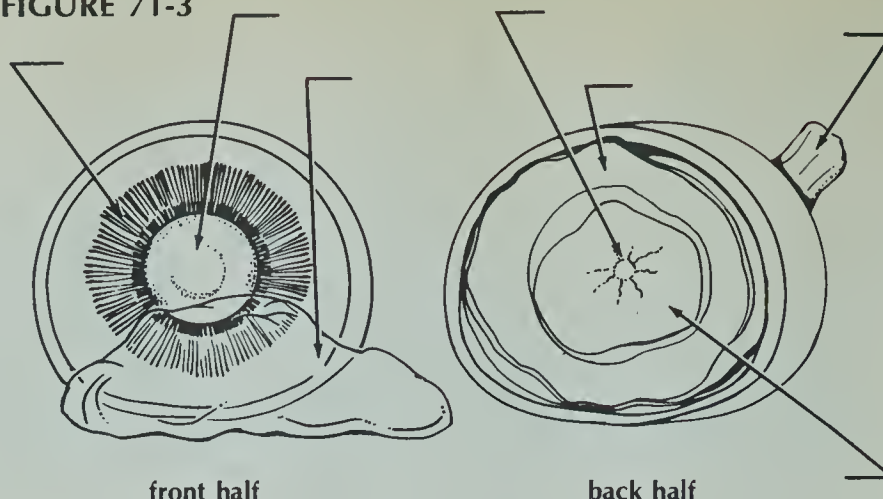


FIGURE 71-3



2. What may be the function of so much fat surrounding the eye?_____

• Once the eye is fairly clean of fat and muscle, use a razor blade (single edge) to cut through the eye using Figure 71-2 as a guide. **CAUTION: Blade is sharp. Slice away from fingers to avoid cuts.**

3. Is the sclera thick or thin?_____

4. Is the sclera a tough tissue or did it cut easily?_____

The eye is now in two halves that should resemble Figure 71-3. Locate the following parts listed in Table 71-2. They are grouped into parts found in the front and back halves.

• Re-examine the front half of the eye. If the lens has not fallen out, carefully remove it with tweezers. Remove any of the vitreous humor that remains.

5. Draw the shape of the lens:
(a) from a side view

(b) from a front view

6. Hold the lens toward the light. Look through it while moving a pencil behind it. Is the lens transparent?_____

• Locate the ciliary muscles. These appear as a circular band surrounding the area where the lens was. They are black and appear to have ridges.

• Look through the oval opening at the front of the eye from the inside. The thin, black layer of tissue surrounding the oval opening is the iris. The center opening in the iris is the pupil.

TABLE 71-2. INTERIOR EYE STRUCTURES

	PART	DESCRIPTION
Front half	Lens	round, clear; located in center of eye
	Vitreous Humor	thick, clear jellylike liquid that spilled from inside of eye
Back half	Retina	thin film of light grey tissue; may have folded in upon itself.
	Tapetum	below retina and covering back of eye; layer of black and bright blue tissue.

• Label the following parts on Figure 71-3: *vitreous humor, retina, tapetum, lens, ciliary muscle, optic nerve.*

• Re-examine the back half of the eye.

• Gently fold the retina back against the tapetum into the retina's normal position. You should now be able to see a small center area where the retina appears to be attached to the back of the eye. This center area is the blind spot. The blind spot is the place all the nerves making up the retina leave the eye to form the optic nerve.

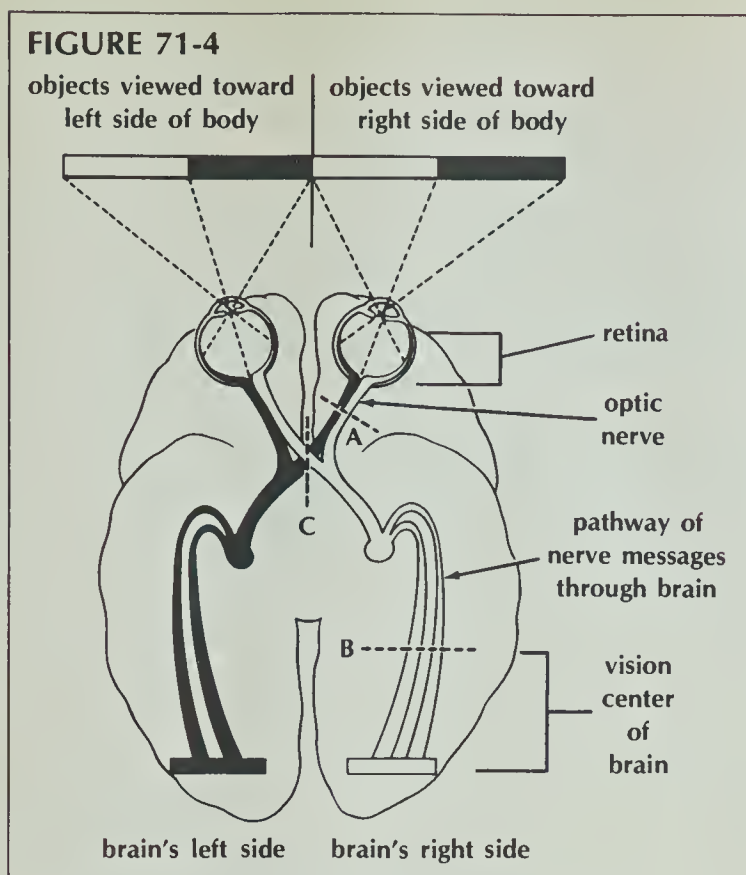
7. Does the blind spot appear directly in line with the optic nerve?_____

• Gently pull part of the tapetum away from the eye to reveal a gray, tough inner eye layer. This layer is the choroid layer.

• Label *blind spot* and *choroid layer* on Figure 71-3.

Part C. Eye and Brain

Figure 71-4 shows a bird's eye view of your brain and eyes. Included in the diagram are the



pathways which nerves follow from the back of the eyes to the brain's vision center.

• Using Figure 71-4, note that the retina in each eye is responsible for receiving light from objects viewed either toward your right or left side.

8. Objects viewed (shaded or unshaded rectangles) toward your right side fall on which side of both eyes' retinas? _____
9. Objects viewed toward your left side fall on which side of both eyes' retinas? _____

Figure 71-4 shows that the optic nerve also is divided into left and right sections from each eye. The pathways follow a pattern toward the back of the brain where once received, the brain interprets what is seen.

10. On which brain side are messages carried by the optic nerve when one views objects
- (a) toward the left side? _____
- (b) toward the right side? _____
11. Does the left optic nerve carry eye messages only to the left brain side? _____
12. Does the right optic nerve carry eye messages only to the right brain side? _____

13. If a person were to damage or destroy the entire vision center of the brain, he/she would not be able to see even though the eyes were not harmed.

(a) A person damages only the left vision center. Could he/she still see? _____

(b) How would the vision be limited? _____

14. (a) A person has the right optic nerve cut by accident at the point marked A on Figure

71-4. Could he/she still see? _____

(b) How would the vision be limited? _____

(c) Which side or sides of the brain's vision center would still be receiving messages? _____

15. (a) A person has the right optic nerve cut by accident at the point marked B on Figure

71-4. Could he/she still see? _____

(b) How would the vision be limited? _____

(c) Which side or sides of the brain's vision center would still be receiving messages? _____

16. (a) A person has the optic nerve cut by accident at the point marked C on Figure

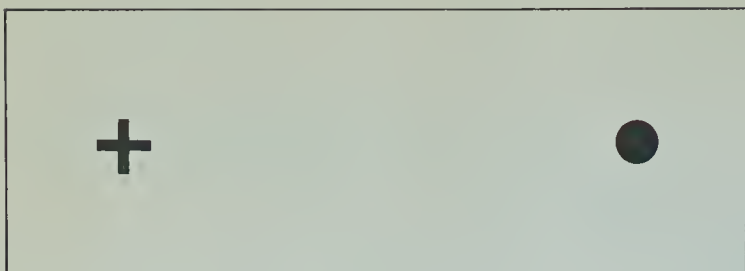
71-4. Could he/she still see? _____

(b) How would the vision be limited? _____

(c) Which side or sides of the brain's vision center would still be receiving messages? _____

17. The blind spot is the area on the retina where all nerves enter the optic nerve. Why is it called the blind spot? If the image of an object lands directly on this spot, one cannot see the object. Prove that a blind spot exists by doing the following. Close your left eye. Stare at the + sign on page 280 and slowly move your lab book toward you. At a certain distance from your eye, the dot will disappear as it comes into focus on the blind spot.

(a) Do you have a blind spot in your right eye? _____



(b) Why might you not have been aware of this blind spot before? _____

Analysis

1. Use your text or other reference to determine the function of the following eye parts:

iris _____

cornea _____

lens _____

vitreous humor _____

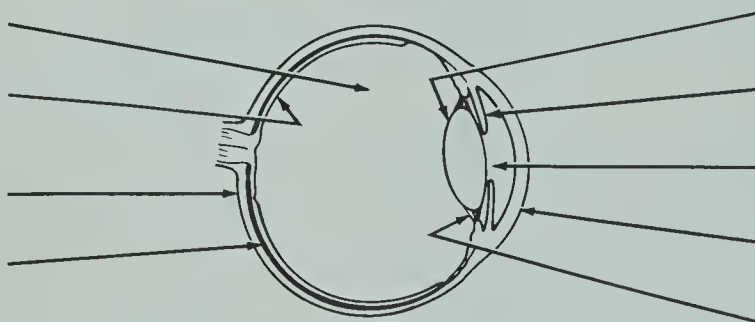
retina _____

choroid _____

ciliary muscles _____

2. Label Figure 71-5, a side view of the human eye. Use the parts listed in question 1 plus these additional labels: *pupil*, *sclera*.

FIGURE 71-5



3. (a) Which part observed in the cow eye does not appear in the human eye? _____
 (b) This part reflects light from the back of the eye. At night, if one were to shine a light in a cow's eyes, they would appear to "shine or glow." What other familiar animals have a tapetum? (Their eyes appear to glow in the dark.) _____
4. (a) On which brain side are objects viewed by your left eye interpreted? _____
 Explain. _____
 (b) On which brain side are objects viewed by your right eye interpreted? _____
 Explain. _____

THE REFLEX ARC

72

There are many actions which take place in your nervous system which do not require your brain. These kinds of actions are called reflexes. Reflexes take place automatically without your having to think about them. Although reflexes do not depend on the brain, they do depend on the spinal cord.

In this investigation, you will:

- (a) study those parts of the spinal cord which are needed for a reflex to occur.
- (b) complete diagrams of a reflex arc.
- (c) experiment with a simple human reflex.

Materials

dissecting microscope or hand lens
 prepared slide of spinal cord cross section
 boiled chicken neck
 clock or watch with second hand

Procedure

Part A. Spinal Cord Cross Section

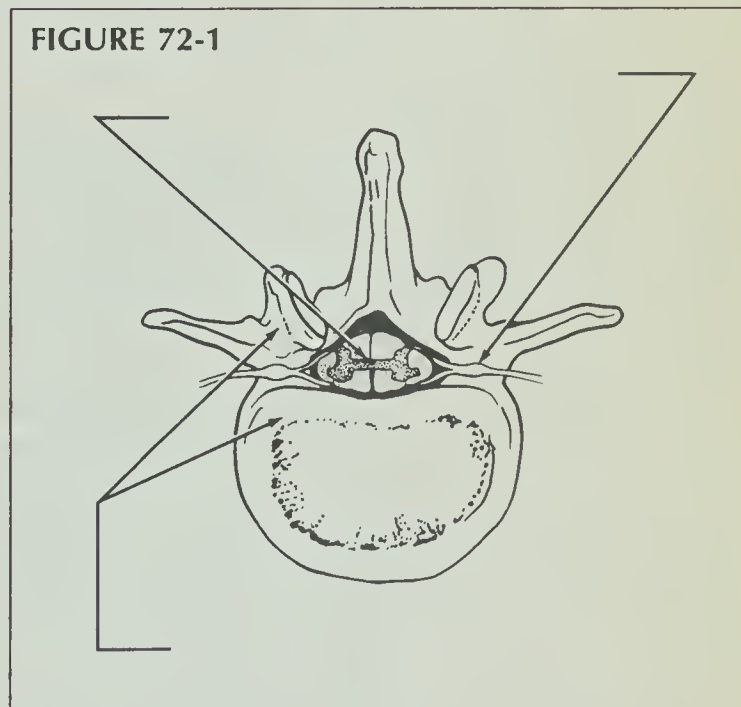
Figure 72-1 shows how the spinal cord and backbone of a human might appear in cross section. The spinal cord is quite small compared to the surrounding bones called vertebrae. Spinal cord (nerve) tissue has been shaded to aid in identification. Nerves leave and enter the spinal cord through spaces between adjoining vertebrae. Nerves appear as stringlike projections extending from the sides of the spinal cord.

● Label the following parts on Figure 72-1: *vertebra*, *spinal cord*, *nerves*. Indicate below each label whether each part is made of bone or nerve cells.

1. What is the major function of the heavy bone which surrounds the spinal cord?_____

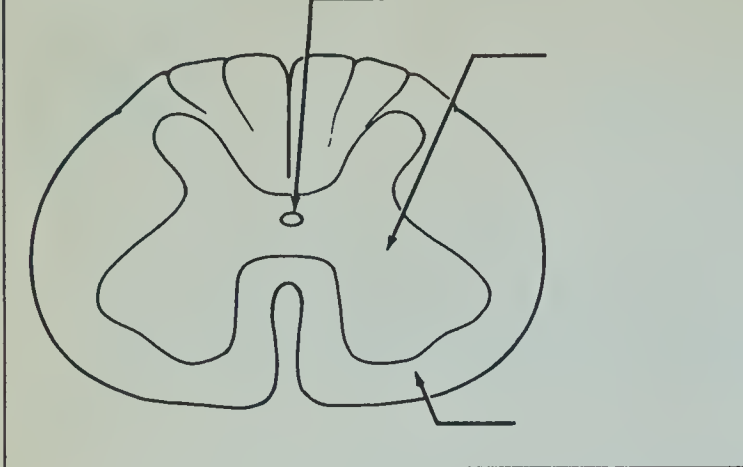
● Examine a boiled chicken neck. The neck of an animal is a continuation of the spinal cord and backbone. By gently twisting, pull off one or two neck vertebrae. After these bones are removed, a thick, smooth structure can be seen sticking out from the bones that remain.

FIGURE 72-1



2. What is the smooth structure that was once enclosed by the vertebrae?_____
3. What might the small side branches be that project from the smooth structure?_____

FIGURE 72-2



• Examine a slide showing a cross section of an animal's spinal cord. Use a dissecting microscope or hand lens.

• Observe the following parts:

- central canal*—small opening in center of spinal cord; spinal fluid passes through this canal.
- grey matter*—section toward the center of the spinal cord; shaped like a letter "H"; should appear darker than the surrounding tissue.
- white matter*—area toward outer edges of spinal cord; surrounds the grey matter; should appear lighter than inner area.

• Label these three parts on Figure 72-2.

Part B. Spinal Cord

Spinal nerves leading to or from various body parts connect to the spinal cord. Nerves connecting along the length of the spinal cord's right side serve body parts of the right side. Nerves connecting along the length of the spinal cord's left side serve body parts on the left side.

Figure 72-3 shows the path of some nerves that connect to the spinal cord. The sensory nerve carries messages from pain detectors in the tip of the finger to the spinal cord. Motor nerves carry messages from the spinal cord to a muscle. Association nerves are located in the grey matter and connect sensory nerves to motor nerves.

Label *sensory*, *association*, and *motor nerves* on Figure 72-3.

4. Compare the relative lengths of the nerve types.

(a) Which nerve is longest? _____

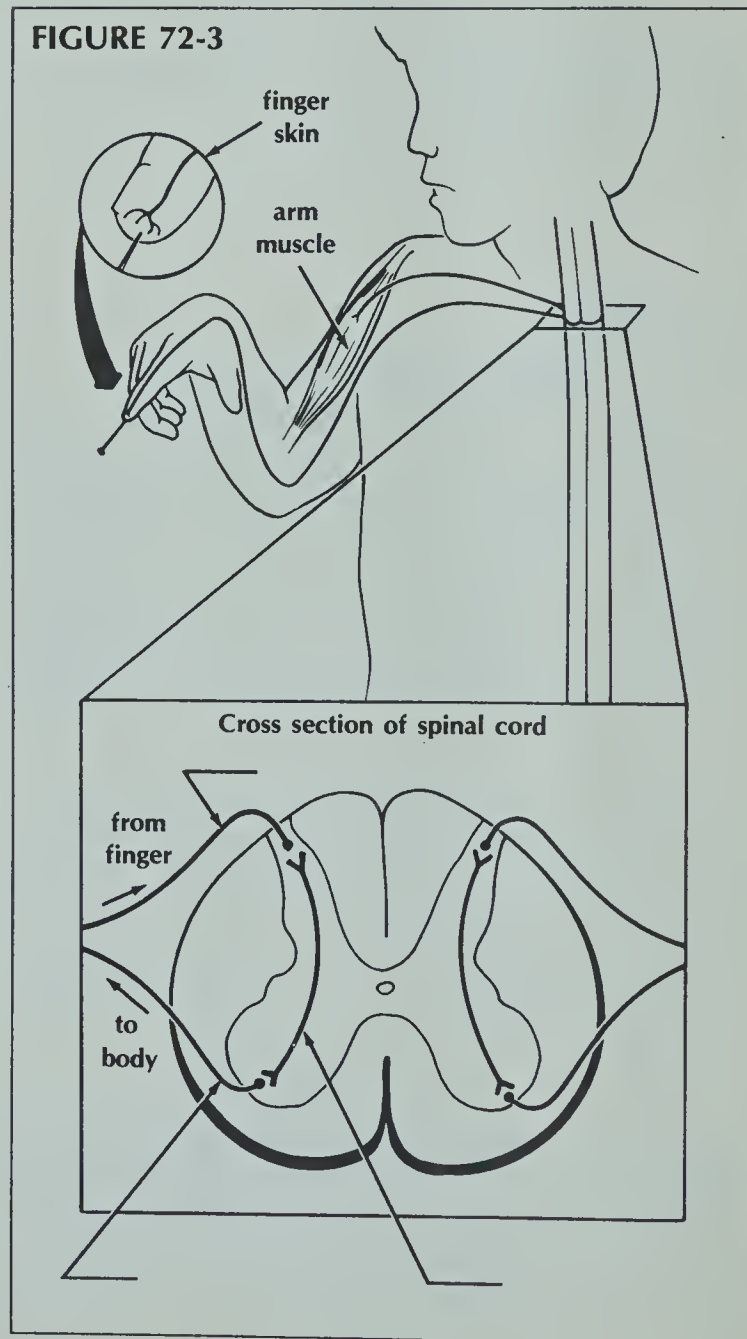
(b) Which nerve is shortest? _____

- How many sensory nerves are shown entering the spinal cord at this specific location? (NOTE: Look at both sides of the spinal cord.) _____
 - How many motor nerves are shown leaving the spinal cord at this specific location? (NOTE: Look at both sides of the spinal cord.) _____
 - Why is this number of sensory and motor nerves necessary? _____

Part C. Movement of Messages Along a Reflex Arc

The interactions of the three nerves just studied is called a reflex arc. When a finger is stuck with a pin, pain detectors in the skin detect the pin

FIGURE 72-3



and a message is sent along the sensory nerve to the spinal cord and the association nerve. The association nerve responds by relaying a message to the motor nerve. The response message travels down the motor nerve to a muscle which reacts by jerking away the hand.

- Trace the pathway of a reflex arc along these three nerves. Draw arrows on Figure 72-3 to indicate the direction of the messages traveling along the nerves.

6. How is the brain involved in a reflex arc?

A reflex such as the one just described is automatic and usually protective in nature. The brain is not consulted and no thinking is done before the action takes place. As a result, the action is very rapid.

7. What are the three nerve types involved in a reflex arc? _____

8. What is meant by an "automatic" reaction?

Part D. An Example of a Reflex

- Look at the eyes of a classmate. Identify the iris and pupil using Figure 72-4 as a guide.

- Diagram in the space marked "before cover" what the iris and pupil of your classmate looks like. Try to make the size of the iris and pupil as accurate as possible.

- Have your classmate cover one of his or her eyes for 30 seconds. After 30 seconds, look at the iris and pupil of the eye that was covered.

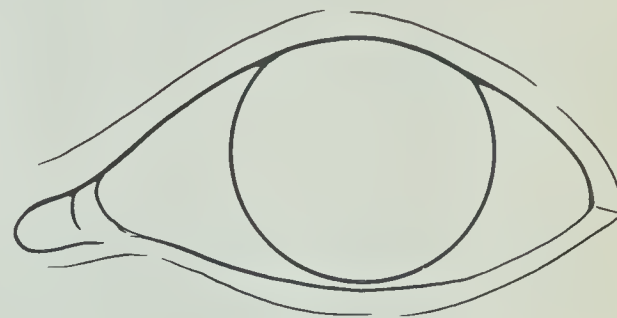
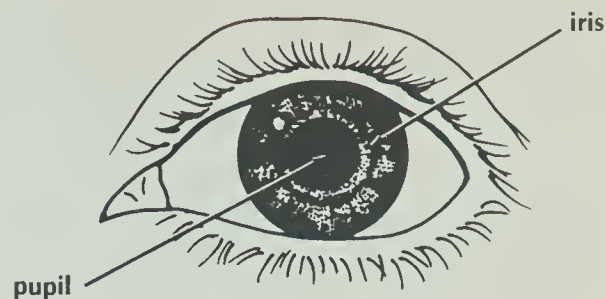
- Diagram in the space marked "after light" what the iris and pupil of your classmate looked like after the cover was removed.

9. How did the pupil and iris sizes change after

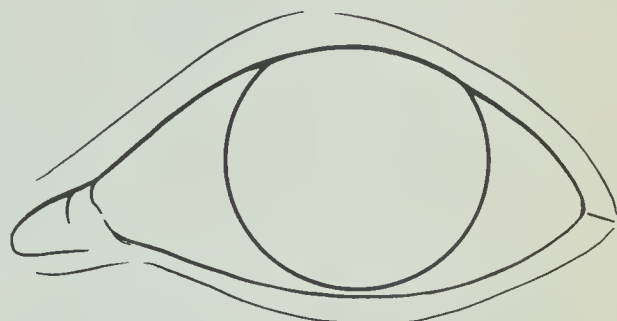
being covered for 30 seconds? _____

10. How do you know that this reaction was a reflex action? _____

FIGURE 72-4



before cover



after light

The muscles in the iris respond to the amount of light present. In dim light the iris enlarges the pupil, allowing more light to enter the eye. In bright light, the iris makes the pupil smaller, and less light enters the eye.

11. How are changes in pupil size protective?

12. (a) What type of nerve detected the bright light? _____

(b) What type of nerve directed the iris muscles to change size and shape? _____

Analysis

1. Define

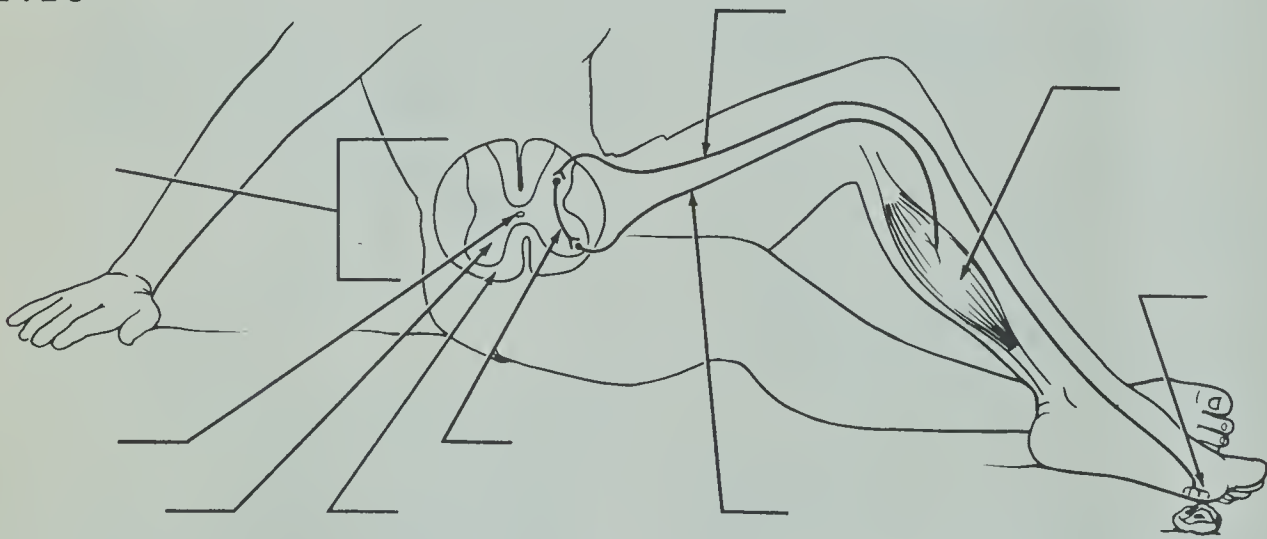
- (a) reflex _____
- (b) reflex arc _____
- (c) vertebrae _____
- (d) motor nerve _____
- (e) sensory nerve _____

2. Using Figures 72-2 and 72-3 as a guide, determine if each of the following nerves ends or begins mainly in white matter or gray matter.

- (a) motor nerve _____
- (b) sensory nerve _____
- (c) association nerve _____

3. (a) Figure 72-5 shows a reflex arc. Label the following parts: *spinal cord, central canal, white matter, gray matter, sensory nerve, sense organ, motor nerve, muscle, association nerve.* (b) Draw arrows on Figure 72-5 showing the direction the messages travel along the nerves.

FIGURE 72-5



4. Describe how the following reflexes might be protective.

- (a) coughing _____
- (b) blinking _____
- (c) jerking your foot away from a sharp stone _____

5. When you stick your finger with a pin, you feel pain. Yet, all pain centers are in the brain. How might your brain receive the "pain" message? _____

6. Explain why you perceive daylight as unusually bright when you come out of a movie theater in the middle of the day. _____

RELIABILITY OF YOUR VISUAL SENSE

73

We assume that the human nervous system is very reliable and that all stimuli received through our sense organs are interpreted accurately. Investigation may provide evidence that our nervous system is or is not always 100% reliable.

In this investigation, you will

- (a) perform a series of tests on the reliability of your visual sense.
- (b) record your observations for each test.
- (c) conclude from your data how reliable your visual sense is.

Materials

colored pencils or crayons: yellow, green, red, black
white unlined paper
straight pin
file card
ruler
page of figures marked A, B, C

lightweight cardboard
glue
pencil with eraser
protractor
paper clip, opened

Procedure

Part A. Afterimages

- With colored pencils or crayons, color the four squares in Figure 73-1. Use only the color indicated for each square.
- Stare at the cross in the center of the colored squares for 30 seconds.
- Then, stare at a white unlined sheet of paper.
- Observe the colors that appear on the white paper and the position of each colored square.

Closing your eyes for one or two seconds while staring at the white paper will help intensify the colors or cause them to remain visible for a longer period of time.

- Repeat the previous three steps as many times as necessary in order to identify each color and its location.

- Record in Table 73-1 the color appearing for each colored square.

FIGURE 73-1

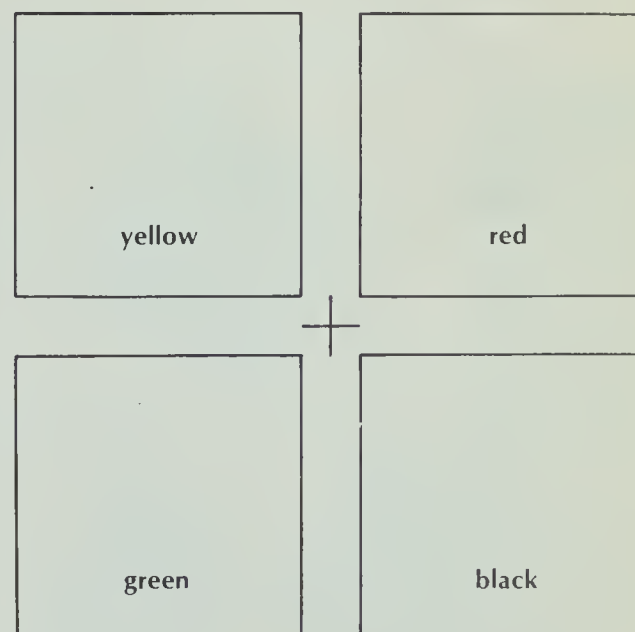
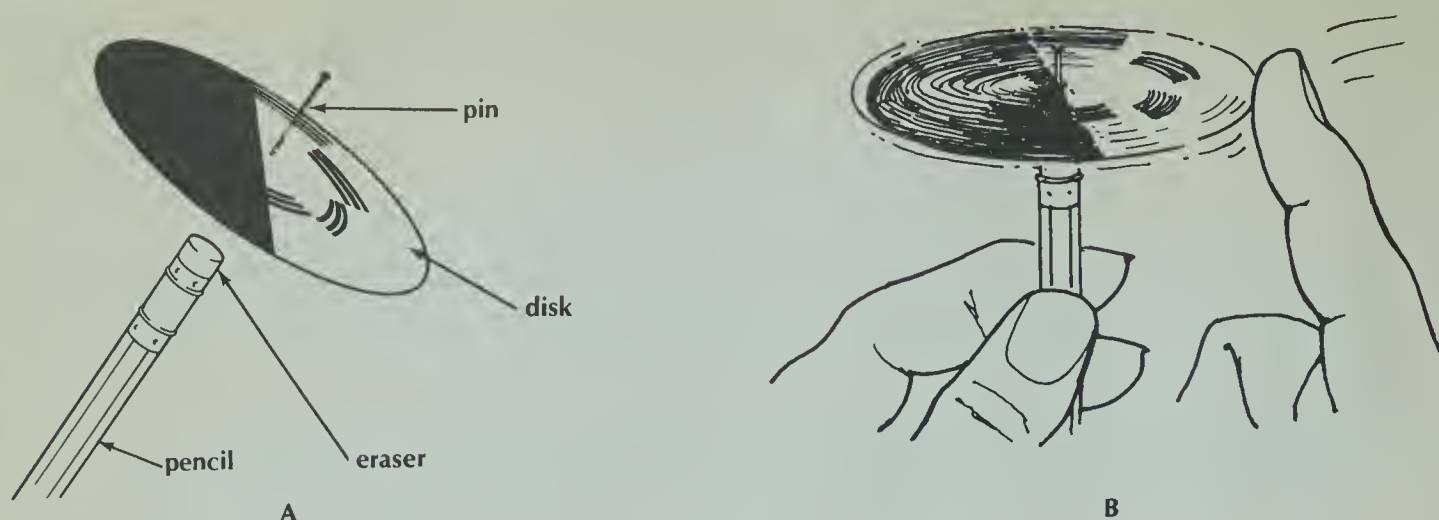


FIGURE 73-2



Part B. Color Wheel

- Cut out the disk marked A from the page provided by your teacher. **CAUTION:** *Always be careful with scissors.*
- Glue the disk to thin cardboard. Trim the cardboard around the disk.
- With a pin, attach the disk to a pencil eraser (Figure 73-2A).
- Spin the disk in one direction by striking the disk's edge with your finger as rapidly as possible (Figure 73-2B).
- Note the appearance of colored bands. Record in Table 73-1 the specific color bands and location of each band.
- Spin the disk in the opposite direction and again note and record in Table 73-1 the colors and location of each band.

Part C. Ambiguous Figure

- Look at Figure 73-3.
- Determine whether you see a series of cubes piled on top of each other toward the left side or toward the right side.
- Look again at the diagram; look continuously for at least 30 seconds.
- Record your observations in Table 73-1.

Part D. Optical Illusion

- Examine Figure 73-4.
- Record in Table 73-1 whether or not you think the figure is a square.
- Use a ruler to determine if each side of the figure is parallel to its opposite side. (Measure the length of opposite sides to determine if they are equal.)

FIGURE 73-3

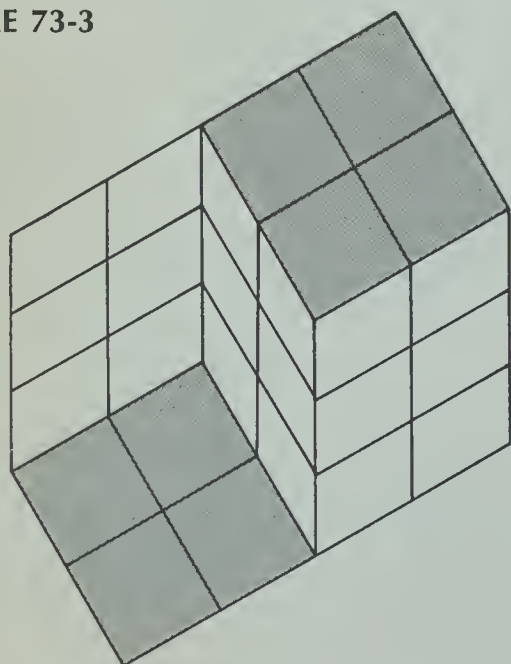


FIGURE 73-4

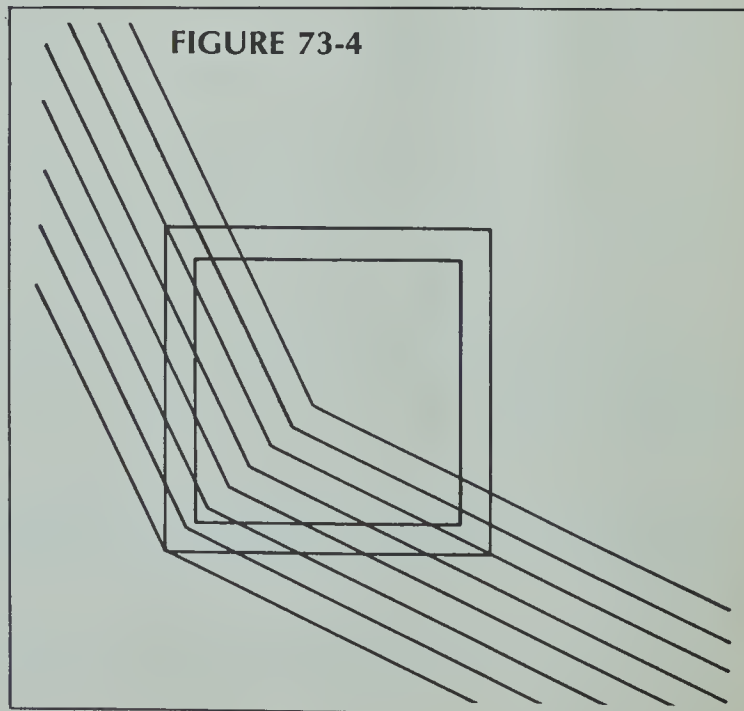


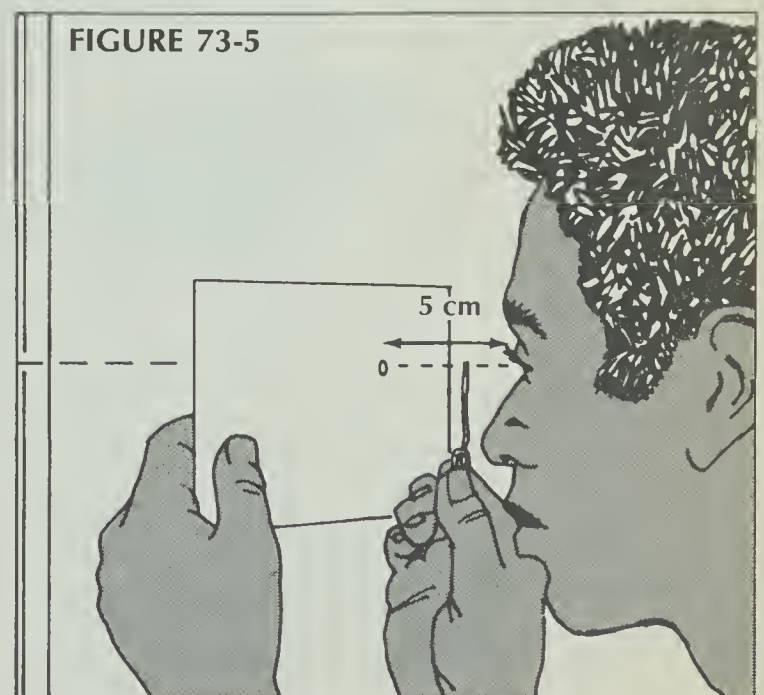
TABLE 73-1. RESULTS OF TESTING YOUR VISUAL SENSE

TEST	OBSERVATIONS
Afterimages	Yellow = _____ Red = _____ Green = _____ Black = _____
Color wheel	One direction— Opposite direction—
Ambiguous figure	
Optical illusion	
Seeing backwards	
Contrast illusion	Disk with triangle— Disk with notch in triangle—
Dot illusion	(a) (b) (c)

- Use a protractor to determine if adjacent sides of the figure form right angles.
- Record your observations in Table 73-1.

Part E. Seeing Backwards

- With a pin, punch a hole in the center of a card.
- Look through the pinhole with one eye while holding the card about 5 cm from your eye. Look toward a light source (windows or ceiling lights).
- Slowly pass an opened paper clip from left to right in front of the pinhole between your eye and the card. Hold the paper clip near your eye. (Figure 73-5). **CAUTION:** *Be extremely careful when holding things near your eyes.*



- Look for the shadow of the clip to appear through the pinhole.
- Note the direction the clip shadow moves as you move the clip from left to right.
- Repeat the previous three steps but now move the clip from right to left.
- Note the direction of the clip shadow as you move the clip up and down.
- Record your observations in Table 73-1.

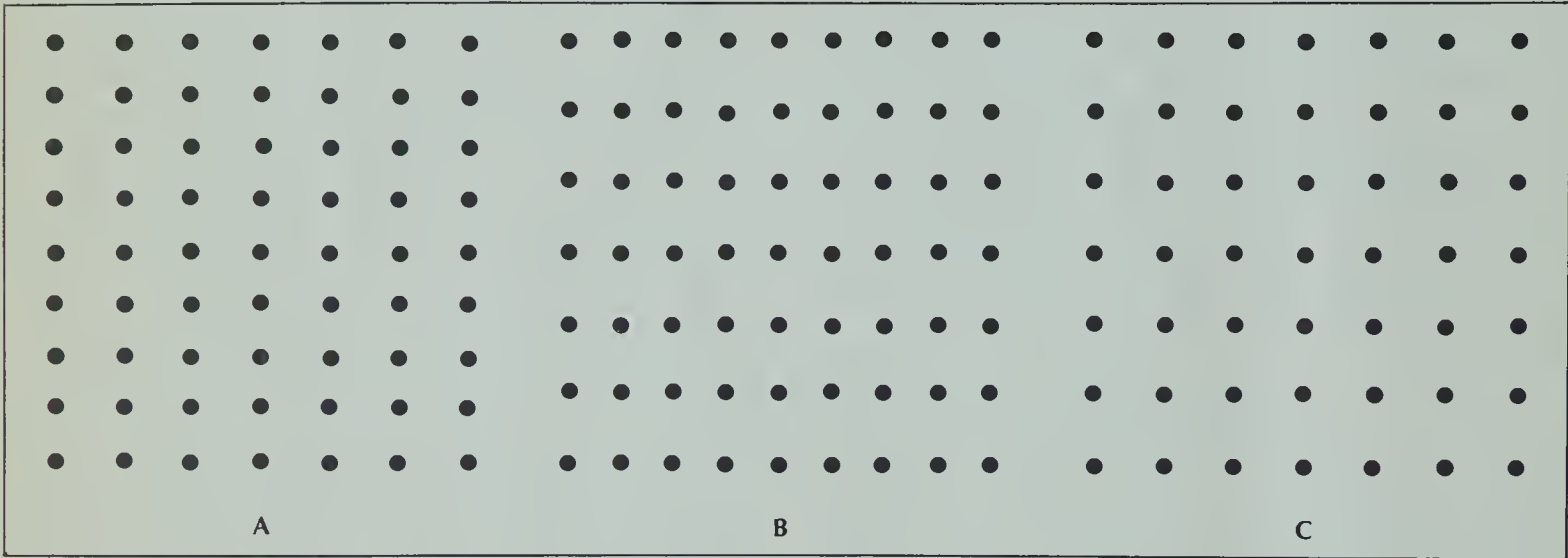
Part F. Contrast Illusion

- Cut out the disk marked B from the handout page. Paste it onto cardboard. Spin it as you did in Part B. Record in Table 73-1 what you see.
- Now cut out and paste disk C from the handout page onto cardboard. Spin it and record in Table 73-1 what you see.

Part G. Dot Illusion

- Examine the three series of similar dots in Figure 73-6A, B, and C. Which way do the dots go? They may all appear to be the same, but look again. Do they go up and down as well as across? Do they only go across? Do they only go up and down? Record which direction the dots go in Table 73-1.

FIGURE 73-6



Analysis

Write a brief report which explains whether or not your visual sense is 100% reliable. Include your data. Draw conclusions about the reliability of your vision from the investigations performed and from other investigations with which you are familiar.

EARTHWORM BEHAVIOR

74

An organism responds to changes in its environment. Biologists refer to these responses as behavior. Behavior may be of two types: unlearned (innate) behavior, or learned (modified) behavior.

In this investigation, you will

- conduct experiments that will show earthworms' unlearned response to light and to gravity.
- observe and record earthworm behavior.
- contribute your data to class totals.
- use class data to determine which experiment provides more easily interpretable earthworm behavior.

Materials

live earthworms
shoe box (or shoe box lid)
paper towels
black paper

scissors
tape
lamp
cardboard

metric ruler
clock or watch with second hand
water

Procedure

Part A. Response to Light

- Prepare an experimental chamber for earthworms by taping black paper over one-half of a shoe box (Figure 74-1).

- Position a lamp above the chamber so that the light shines directly on it.

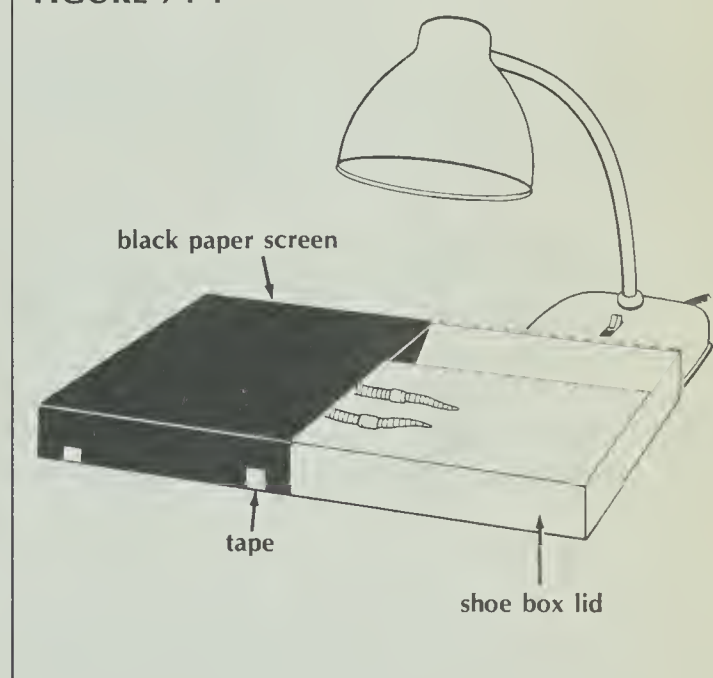
- Place wet paper towels in the shoe box.

- Place two (or more if available) earthworms in the chamber so that their anterior ends are in the light and their posterior ends are under the paper screen. NOTE: The anterior end of a worm is closest to the bandlike structure (clitellum). This band appears orange-brown on live animals.

- Wait five minutes. Then record in Table 74-1 the number of worms whose anterior ends are still in the light and the number of worms whose anterior ends are now under the paper screen (in the dark).

- Repeat this procedure for four more trials. Reposition all worms with their anterior ends in the light at the start of each new trial. Record your observations for each trial.

FIGURE 74-1



- Repeat the entire procedure for five trials of five minutes each. However, now position the worms so that anterior ends are placed under the paper screen and posterior ends are in the light at the start of each new trial.

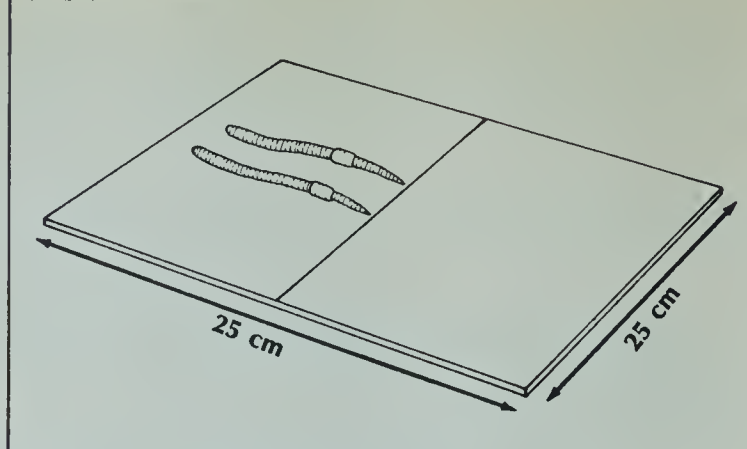
TABLE 74-1. RESPONSE TO LIGHT				
	ANTERIOR END IN LIGHT AT START		ANTERIOR END IN DARK AT START	
Trial	Anterior end in light	Anterior end in dark	Anterior end in light	Anterior end in dark
1				
2				
3				
4				
5				
Individual totals				
Class totals				

- Record your observations for each trial in Table 74-1. Total all data from each column. Record this number under "Individual totals."
- Record class totals in Table 74-1.

Part B. Response to Gravity

- Cut a square piece of cardboard to measure 25 cm on each side.
- Draw a line across the middle of your cardboard.
- With the cardboard flat on your desk, position your earthworms so that the anterior end of each worm is on the line (Figure 74-2).
- Wait exactly one minute. Count the number of worms whose anterior ends have moved over the line, the number whose anterior ends have moved behind the line, and the number that have not moved at all. NOTE: If a worm turns to the side, judge its position in relation to where its anterior end lies (either in front or behind the line).
- Record your observations in Table 74-2.
- Record results for nine more one-minute trials. Remember to reposition all worms at the start of each new trial.
- Tip your cardboard at an angle of about 10° with the table top. Support the cardboard with a book (Figure 74-3).

FIGURE 74-2



- Position all worms so that their anterior ends are on the line and the worms are facing toward the high end of the cardboard.
- Wait one minute. Then record in Table 74-2 the number of worms whose anterior ends have moved up (crossed the line), moved down, and have not moved.
- Record in Table 74-2 nine more one-minute trials. Remember to reposition all worms at the start of each new trial.
- Repeat the entire procedure, using ten one-minute trials. However, now position all worms so that their anterior ends are on the line and they are facing the low end of the cardboard (Figure 74-4).
- Record all results in Table 74-2. Total data for each column. Record this number under "Individual totals."
- Record class totals in Table 74-2.

FIGURE 74-3

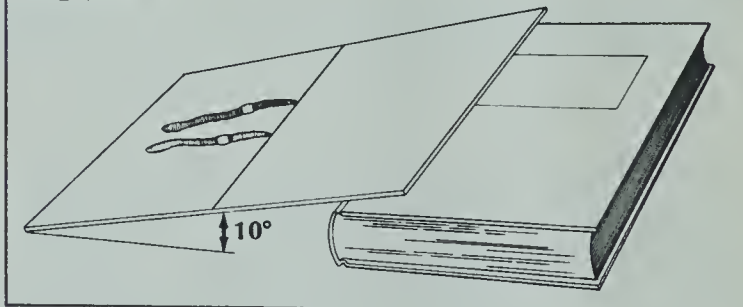


FIGURE 74-4

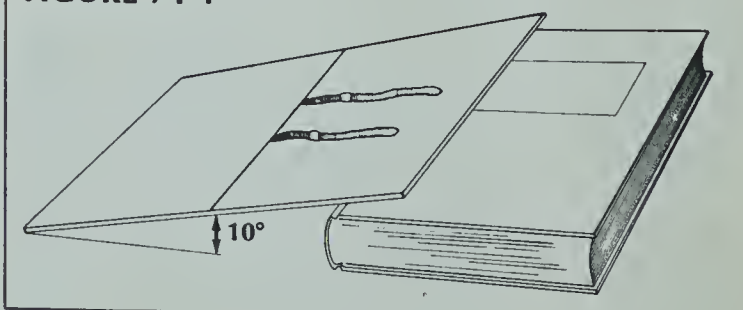


TABLE 74-2. RESPONSE TO GRAVITY

TRIAL	WORMS FLAT ON DESK			WORMS FACING UP AWAY FROM GRAVITY			WORMS FACING DOWN TOWARDS GRAVITY		
	ANTERIOR END OVER LINE	ANTERIOR END BEHIND LINE	NO CHANGE	ANTERIOR END OVER LINE	ANTERIOR END BEHIND LINE	NO CHANGE	ANTERIOR END OVER LINE	ANTERIOR END BEHIND LINE	NO CHANGE
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
Individual totals									
Class totals									

Analysis

1. Briefly restate the specific behavior being tested in Part A of this investigation. _____

2. Using class totals, explain how the earthworm's behavior is influenced by light when
 - (a) anterior ends are placed in light. _____

 - (b) posterior ends are placed in light. _____

3. On the basis of your answers to question 2, offer experimental evidence which explains whether or not all areas of the earthworm's body respond equally to light or dark. _____

4. (a) Does the earthworm's response to light have any adaptive or protective value? _____
(b) Explain. _____

5. Briefly restate the behavior being tested in Part B of this investigation. _____

6. Using class totals only, what conclusions may be made about the earthworm's response to gravity? (If an earthworm responds by moving toward gravity, it is positively geotactic; if it moves away from gravity, it is negatively geotactic.) _____
7. (a) If you were to choose between the experiment in Part A and the one in Part B on the basis of reliable and accurate data, which would you choose? _____
(b) Why? _____
8. On the basis of your answer to question 7, explain why experiments on animal behavior may be difficult to conduct and interpret. _____

A YEAST POPULATION STUDY

75

A population study of living organisms may be difficult in the laboratory for several reasons. Reproductive cycles of some organisms can take months or years. Proper maintenance and growth of a population under ideal conditions may be difficult. Also, accurate counting of actual numbers of a population often requires elaborate equipment or sampling techniques. Study of a population in a laboratory is artificial compared to an actual population in nature. Many environmental factors which are interrelated in nature cannot be duplicated in a laboratory.

Biologists often study population trends using microorganisms such as yeast. The problems listed above are lessened somewhat when dealing with this type of organism. Yeasts can be maintained easily in test tubes, they reproduce rapidly under ideal conditions, and a simple sampling technique can be used to count a yeast population.

In this investigation, you will

- (a) use a sampling technique to determine density changes in a yeast population.
- (b) compare the number of cells present at the start of a yeast population with the number present during later time intervals.
- (c) calculate and graph the actual number of cells present in the yeast population.
- (d) apply the principles responsible for changes in the yeast population to the human population.

Procedure

Figure 75-1 represents population samples taken from a test tube yeast population. The samples are on special glass slides with lines etched on them. Each figure represents the view as seen through a microscope.

- Count the total number of yeast cells (small circles) in each of the three samples for 0 hours.

As an aid in counting, the areas are divided into 16 small squares. You may wish to place a pencil dot inside those cells counted so that you do not count any twice.

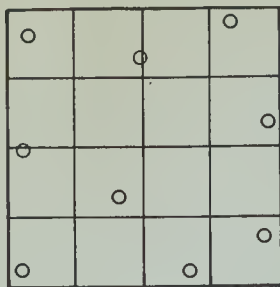
- Record in Table 75-1 the number of cells counted in each of the three areas for 0 hours of growth.
- Determine and record in the proper column of Table 75-1 the total number of cells for 0 hours.
- Compute the average number of yeast cells per area to one decimal place. Record the average in Table 75-1.

- Repeat the four previous steps for yeast samples at 24, 48, 72, 96, and 120 hours.

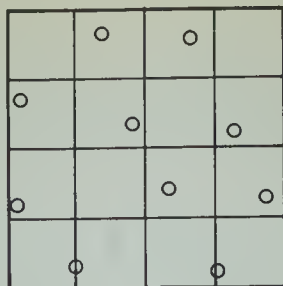
All cells in the test tube population were not counted on the glass slides. Only a small sample was counted. Thus, this method of determining population is called a sampling technique. Multiplying all average yeast cell counts in Table 75-1 by 1000 will give an estimate of the number of cells in the entire population. A volume equal to only 1/1000 the original yeast population was placed on the counting slides.

- Record in the row "Entire Population" of Table 75-1 the total number of yeast cells in the population.
- In Figure 75-2, construct a graph of your data. Use values representing the total number of yeast cells (entire population) present during 0, 24, 48, 72, 96, and 120 hours.

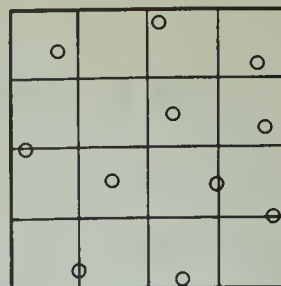
0 hours



A

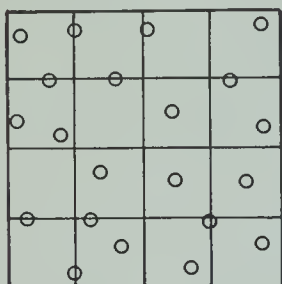


B

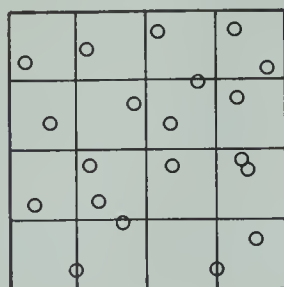


C

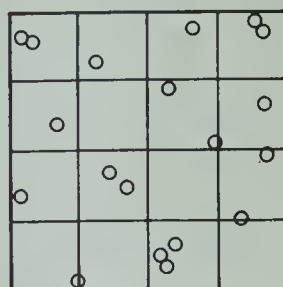
24 hours



A

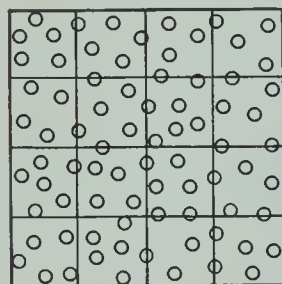


B

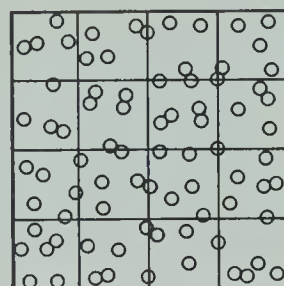


C

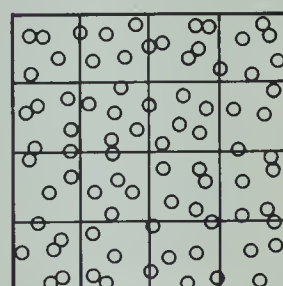
48 hours



A

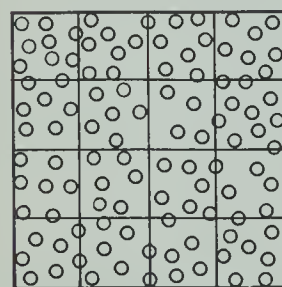


B

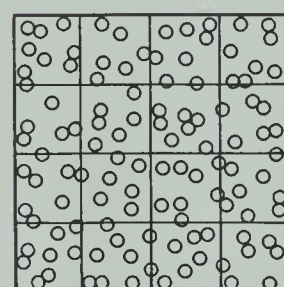


C

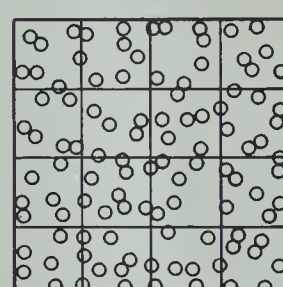
72 hours



A

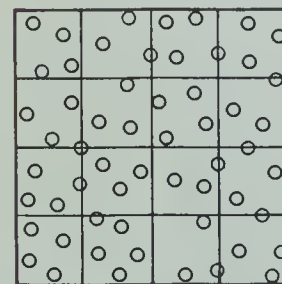


B

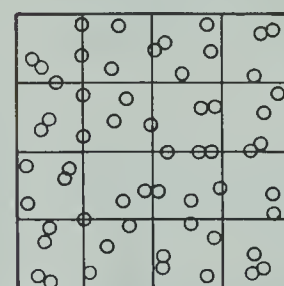


C

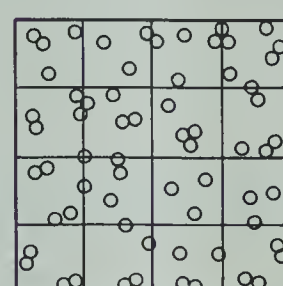
96 hours



A

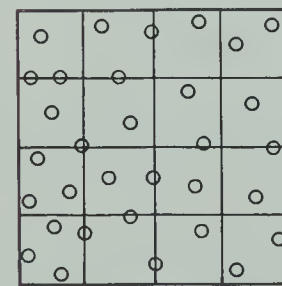


B

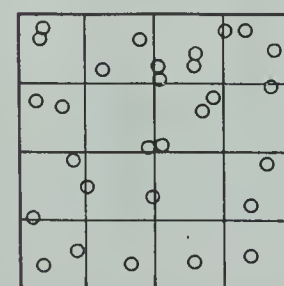


C

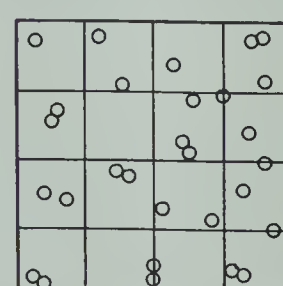
120 hours



A



B



C

FIGURE 75-1

TABLE 75-1. SAMPLES OF YEAST POPULATION						
HOURS →	NUMBER OF CELLS					
	0	24	48	72	96	120
Area A						
Area B						
Area C						
Total						
Average						
Entire population (Average × 1000)						

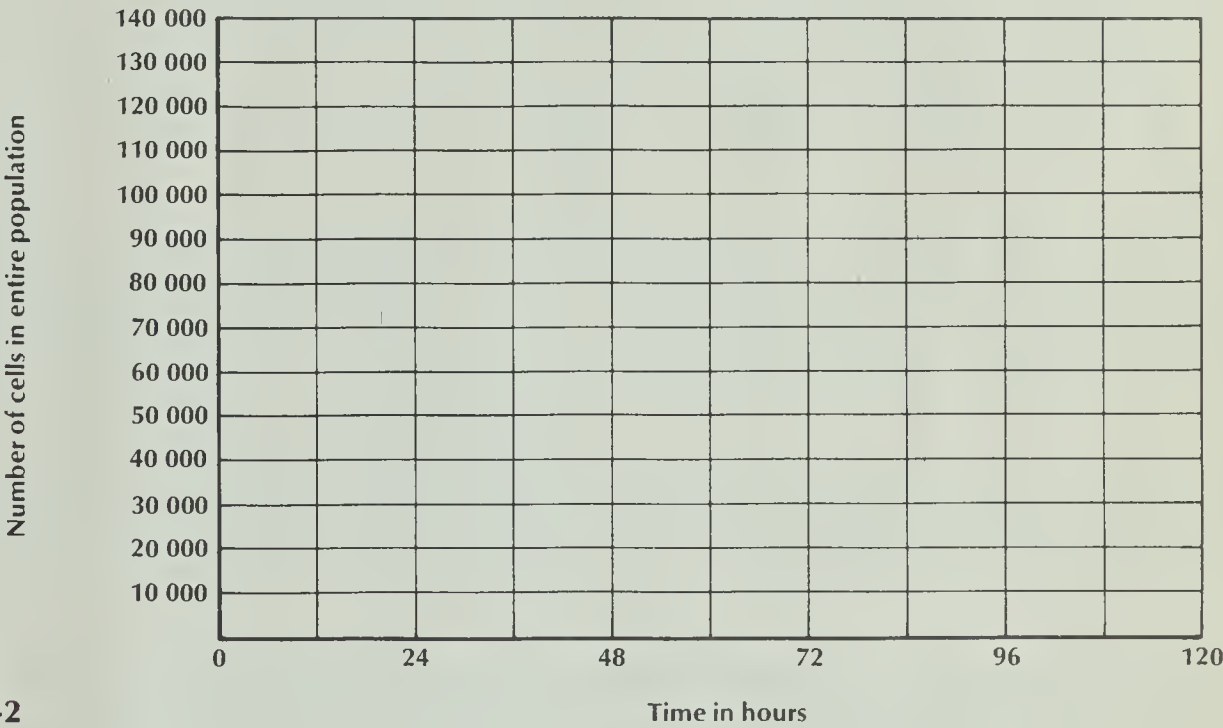


FIGURE 75-2

Analysis

1. From the graph, determine the change in population size between
- (a) 0 and 24 hours. _____
- (b) 24 and 48 hours. _____
- (c) 48 and 72 hours. _____
- (d) 0 and 72 hours. _____
2. During which time interval (0-24, 24-48, and so on) is growth most rapid? _____
3. During which time interval (0-24, 24-48, and so on) is growth slowest? _____

4. When did this yeast population reach a peak (no further increase in growth occurred)? _____
5. What happened to this yeast population after it reached its peak (maximum)? _____
6. After reaching a peak, the yeast population began to decline. What may have caused this? _____
7. From the graph in Figure 75-3, determine the changes in the human population occurring between
 - (a) 1700 and 1800. _____
 - (b) 1800 and 1900. _____
 - (c) 1900 and 2000. _____

NOTE: The dashed portion of the graph line is an estimate of the population in future years based on the current rate of increase.

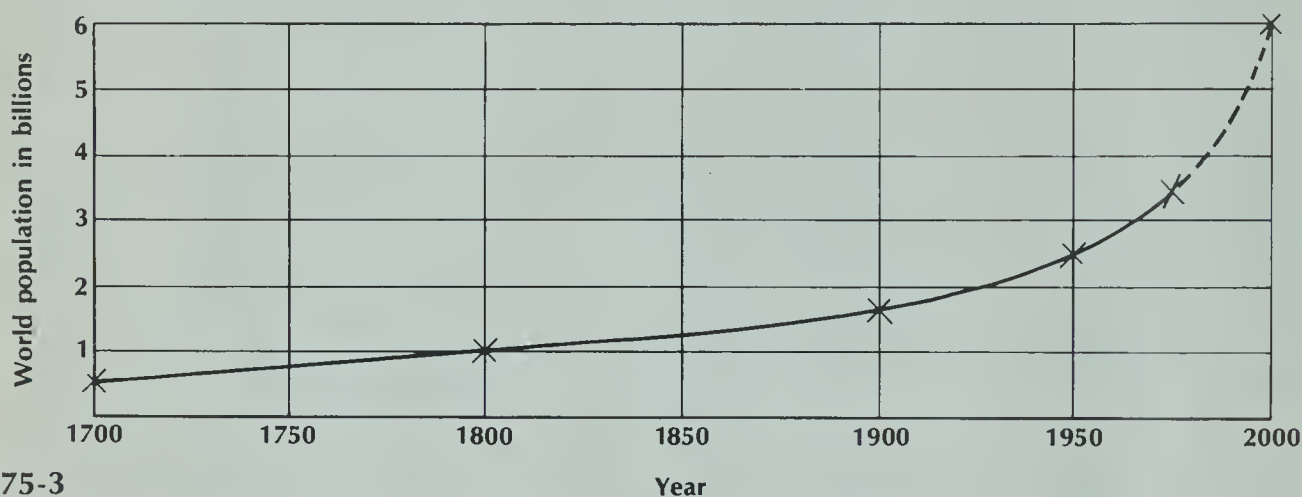


FIGURE 75-3

8. It took 125 years (1800-1925) for the human population to increase in size by 1 billion.
 - (a) How many years were needed to increase by another 1 billion (from 2 to 3 billion)? _____
 - (b) How many years is it expected to take for the next 1 billion increase (from 3 to 4 billion)? _____
 - (c) What trend is occurring within the human population as far as the amount of time needed to increase population by 1 billion. _____
9. Has the human population reached a peak similar to the yeast population? _____
10. What do you think may happen to the human population if it continues to increase? _____
11. Explain how each of these factors may be important in influencing human population growth.
 - (a) crowding or available space _____
 - (b) food availability _____
 - (c) chemicals produced as "waste products" _____

CHANGES IN THE SURVIVAL RATE OF POPULATIONS

Governments periodically take a census, or count, of the population. Data gathered in a census are analyzed and compared to previous censuses in order to determine trends occurring in a population. Types of data gathered include death rates and numbers of people surviving in each age group. This information can be used to plot a survivorship curve which shows the number of people surviving in each age group.

In this investigation, you will

- compare the death rate by age groups for a sample of a late 19th century population to that of a sample of an early 20th century population
- prepare survivorship curves for both population groups.
- compare these survivorship curves and thus be able to describe changes that took place in the population between the 19th and 20th centuries.

Materials

colored pencils (or pens)

Procedure

Part A. Calculating 19th and 20th Century Population Data

Because it is so difficult to work with large numbers, we will work with only samples of the populations of both centuries. Table 76-1 uses a sample of 1000 people who lived in the late 19th century. What is true for these 1000 people is generally true for the entire population during the same period.

Column A of Table 76-1 lists by age groups the number of people out of 1000 who died during the late 19th century. (These numbers were gathered by checking tombstone dates in a cemetery.)

- Complete Table 76-1. Calculate the data for columns B and C. Column B is to be completed as follows. At the beginning of the age interval 0-10, all 1000 people are surviving. Thus, the first number in Column B is 1000. (This number is provided for you in the table.) To complete the number surviving in the other age groups, subtract the number dying (Column A) from the number surviving in the previous age group (Column B).

Example: Compute the number surviving at the start of age interval 11-20. Subtract the number of people who died in interval 0-10 (104) (Column A)

from the number surviving at the beginning of interval 0-10 (1000) (Column B). $1000 - 104 = 896$, the number of people surviving at the beginning of interval 11-20.

For the interval 21-30, repeat this process using the numbers from the interval 11-20 ($896 - 36 = 860$). Complete the rest of Column B in this manner.

- Complete Column C as follows: This column lists the average number of people alive throughout the age interval. Take half the value for each age group in Column A and subtract it from the number directly across from it in Column B. Example: For the age interval 0-10, divide 104 (from Column A) by 2 (52). Subtract this number from 1000 (Column B) to get 948 (Column C).

For the age interval 11-20, divide 36 (from Column A) by 2 (18). Subtract this number from 896 (Column B) to get 878 (Column C). Complete the rest of Column C in this way.

- Complete Table 76-2 just as you did Table 76-1. Table 76-2 shows the population data for an early 20th century population.

TABLE 76-1. LATE 19TH CENTURY SAMPLE
POPULATION DATA (1850-1899)

AGE (YEARS)	A NUMBER DYING	B NUMBER SURVIVING AT START OF INTERVAL	C AVERAGE NUMBER ALIVE
0-10	104	1000	
11-20	36		
21-30	152		
31-40	116		
41-50	116		
51-60	132		
61-70	132		
71-80	124		
81-90	84		
91-100	4		
100 +	0		

TABLE 76-2. EARLY 20TH CENTURY SAMPLE
POPULATION DATA (1900-1950)

AGE (YEARS)	A NUMBER DYING	B NUMBER SURVIVING AT START OF INTERVAL	C AVERAGE NUMBER ALIVE
0-10	20	1000	
11-20	32		
21-30	52		
31-40	28		
41-50	88		
51-60	156		
61-70	240		
71-80	268		
81-90	116		
91-100	0		
100 +	0		

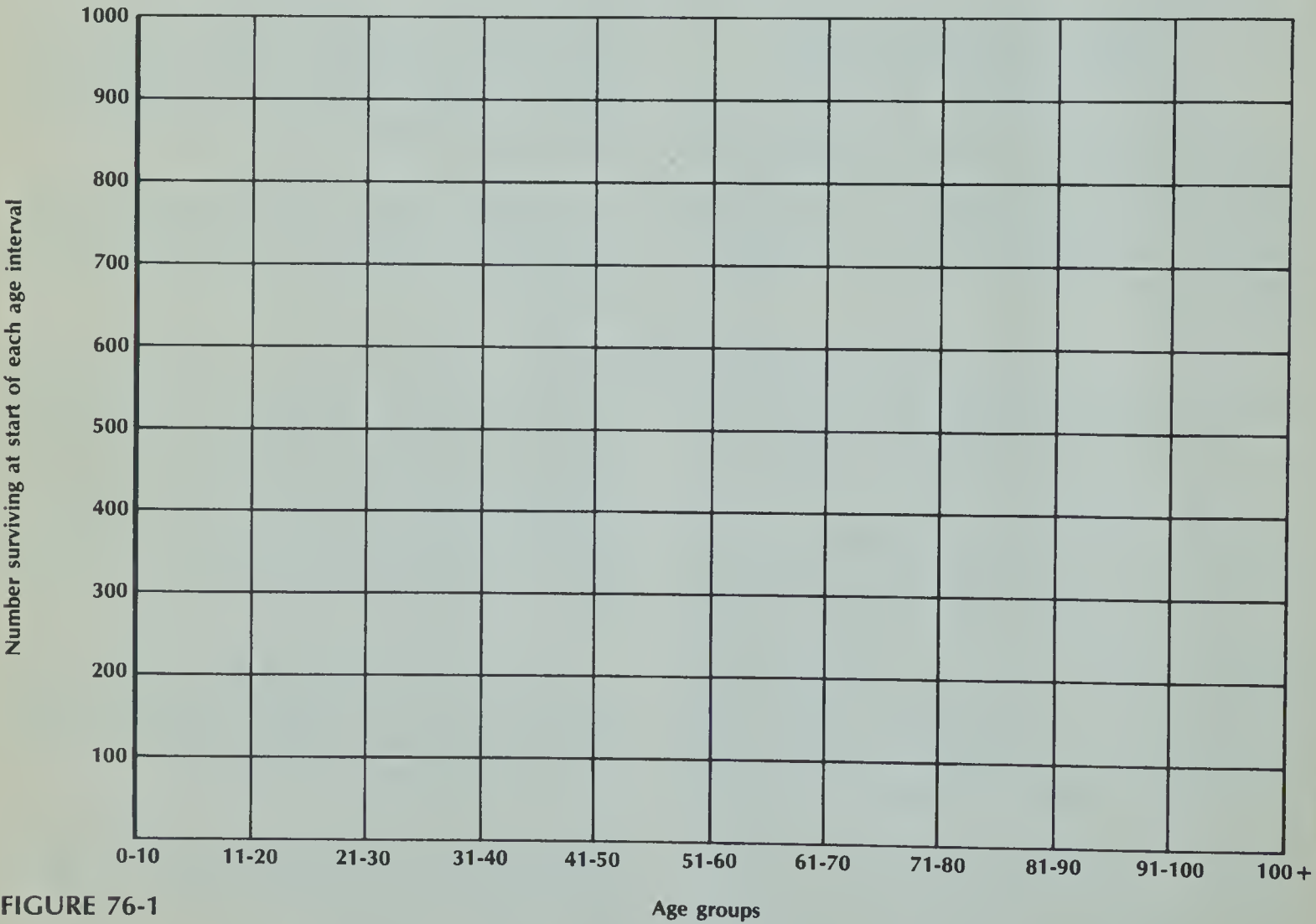


FIGURE 76-1

Age Interval	Century										
100 +	20										
	19										
91-100	20										
	19										
81-90	20										
	19										
71-80	20										
	19										
61-70	20										
	19										
51-60	20										
	19										
41-50	20										
	19										
31-40	20										
	19										
21-30	20										
	19										
11-20	20										
	19										
0-10	20										
	19										

0 100 200 300 400 500 600 700 800 900 1000

FIGURE 76-2

Average number of people still alive in each age interval

- The average life span for a late 19th century population can be computed as follows: Total up all the numbers in Column C of Table 76-1. Divide this number by 100.

1. What was the average life span for a person living in the late 19th century? _____

- The average life span for a 20th century population can be computed as follows: Total up all numbers in Column C of Table 76-2. Divide this number by 100.

2. What was the average life span for a person living in the early 20th century? _____

Part B. Plotting a Survival Curve

- Construct a line graph on Figure 76-1 using the data from Column B in Tables 76-1 and 76-2. Make two lines on this graph using different colors for each century.

- Label the lines as to which century each represents.

Part C. Comparing Survival by Age Groups

Construct a bar graph on Figure 76-2 using the data from Column C in Tables 76-1 and 76-2. Use different colors for each century and label the graphs.

Analysis

1. Using Figure 76-1, tell which population's individuals had the best chance of surviving at the age of

(a) 11-20 years. _____

(b) 31-40 years. _____

(c) 71-80 years. _____

2. Why do you think that the early 20th century population shows a higher survival rate at almost every age group? _____

3. Using your graph which compares average number of people still alive in each age group (Figure 76-2),
 - (a) list the age group showing the biggest difference between 19th and 20th century populations.

 - (b) list the age group showing the next biggest difference. _____
 - (c) list the age group showing the least difference (do not use the 90-100 or 100+ age groups).

4. When comparing average 19th and 20th century life spans, what trend seems to be occurring in the population? _____
5. Using the graph in Figure 76-3, predict and draw the survivorship curves for an early 19th century population and a late 19th century population.

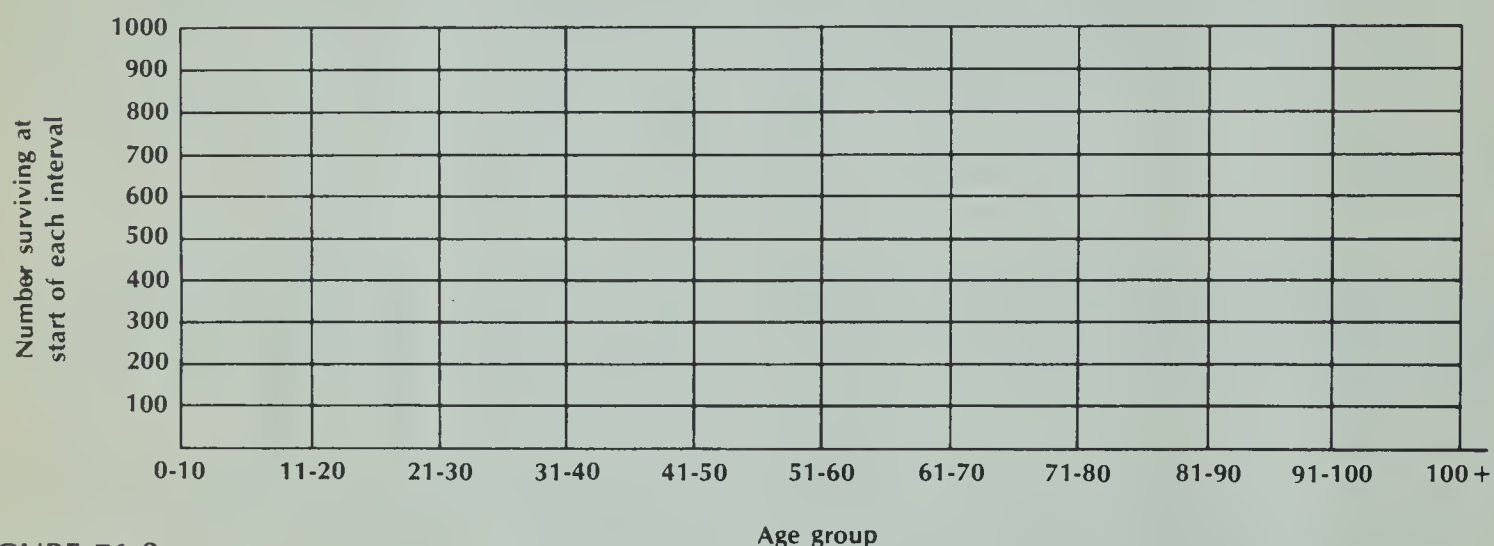


FIGURE 76-3

6. Using the graph in Figure 76-4, predict and draw the survivorship curves for an early 20th century population and a late 20th century population.

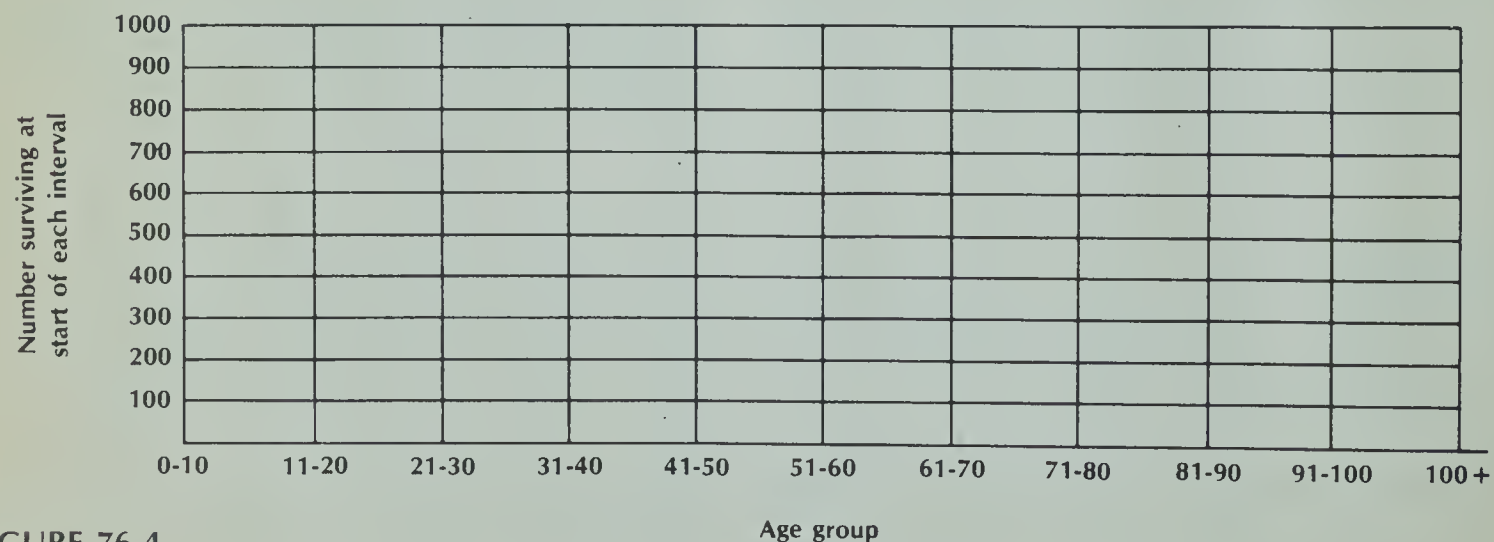


FIGURE 76-4

TESTING WATER QUALITY

77

One way of judging water quality is to determine the amount of oxygen gas and carbon dioxide gas dissolved in the water. Polluted water often has a low oxygen content. It may also have a high carbon dioxide content. Clean water usually has a high oxygen content.

Oxygen and carbon dioxide may be supplied to a body of water from the air. Oxygen and carbon dioxide may also be supplied when living things within the water carry on photosynthesis and respiration.

In this investigation, you will

- measure and record the amount of dissolved oxygen and carbon dioxide in water samples.
- use your data to determine the parts per million (ppm) of dissolved oxygen and carbon dioxide in each sample.
- evaluate whether your water samples may be polluted or clean.

Materials

For Part A:

water samples from 2 different sources
small flasks (or beakers)—2
droppers (1 for each solution)
labels
solution A—48% manganous sulfate
solution B—70% potassium hydroxide and 15% potassium iodide
solution C—concentrated sulfuric acid
solution D—2% starch
solution E—0.31% sodium thiosulfate

For Part B:

water samples from 2 different sources
small flasks (or beakers)—2
dropper
labels
phenolphthalein solution
0.4% sodium hydroxide solution

CAUTION: All chemicals used are harmful to skin and clothing. If you spill any chemical, rinse with water and call your teacher immediately.

Procedure

Part A. Dissolved Oxygen

- Obtain 100 mL of two different water samples.
- Place the samples in small flasks (or beakers).

If you are to pour samples into the flasks from large containers, pour slowly to avoid bubbling (aerating) the water. If you are collecting samples directly from the source, open the flasks under the water so the flasks fill with water below the surface.

- Label the flasks with the source of the water. Also record in Table 77-1 where each sample was obtained.

- With a dropper, add 10 drops of solution A to each water sample. Hold the dropper close to the water surface to avoid splashing.

- With another dropper, add 10 drops of solution B to each water sample.

TABLE 77-1. RESULTS OF OXYGEN AND CARBON DIOXIDE TESTS

OXYGEN RESULTS			CARBON DIOXIDE RESULTS			
Water Source	Drops of Solution E Used	Amount of O ₂ (PPM)	Water Source	Carbon Dioxide Present?	Drops of Sodium Hydroxide Used	Amount of CO ₂ (PPM)

- Gently mix the contents by swirling the flasks. However, be careful to avoid forming bubbles.

- After swirling, let the flasks stand for one minute. (If you are using seawater as a sample, it must stand for 15 minutes.)

- With a third dropper, add 15 drops of solution C to each water sample.

- Gently mix the contents by swirling the flasks. Again, be careful to avoid splashing.

- While gently swirling each flask, add five drops of solution D to the sample. A deep blue color will appear.

- With a dropper, add solution E one drop at a time to each sample. The number of drops of solution E must be counted.

- Add drops of solution E until the water sample becomes colorless. Swirl the water samples after the addition of each drop in order to determine the true color of the solution.

- Count and record in Table 77-1 the number of drops of solution E needed to turn each water sample colorless.

The amount of dissolved oxygen in water usually is described in terms of parts of oxygen per million parts of water. For example, at room temperature, fresh water has 8.4 parts of dissolved oxygen per one million parts of water (8.4 ppm).

- Convert the drops of solution E to ppm of oxygen in each flask by dividing the numbers of drops of solution E (Table 77-1) by 20. Carry your divisions to one decimal place.

- Record the ppm of dissolved oxygen for each sample tested in Table 77-1.

Part B. Testing for Carbon Dioxide

- Obtain 100 mL of two different water samples. Place the samples in small flasks (or beakers).

- Label the flasks with the water source. Also record in Table 77-1 the water source.

- With a dropper, add 5 drops of phenolphthalein solution to each sample. Mix by gently swirling your flasks. NOTE: If a light pink color forms and stays, no carbon dioxide is present. Record this result in Table 77-1. You are finished testing this water sample. If the pink color forms and then quickly disappears, carbon dioxide gas is present. Go on with the procedure.

- With a clean dropper, add sodium hydroxide one drop at a time to each sample. The number of drops of this chemical that you add must be counted. Swirl the water samples after the addition of every few drops to determine the true color of the water.

- Add drops of sodium hydroxide until the water sample becomes light pink and remains pink after swirling.

- Record the number of drops of sodium hydroxide needed to change the color of the sample.

- Convert the drops of sodium hydroxide to ppm of carbon dioxide in each flask by multiplying the number of drops used by five.

- Record the ppm of carbon dioxide in each sample tested in Table 77-1.

Analysis

1. (a) Which water sample contains more dissolved oxygen? _____
(b) Which contains less dissolved oxygen? _____
2. A lake sample having less than 4 ppm dissolved oxygen is harmful to most fish.
(a) Which of your samples could have come from a lake that will support most fish? _____

(b) Which samples could not? _____
(c) Explain. _____

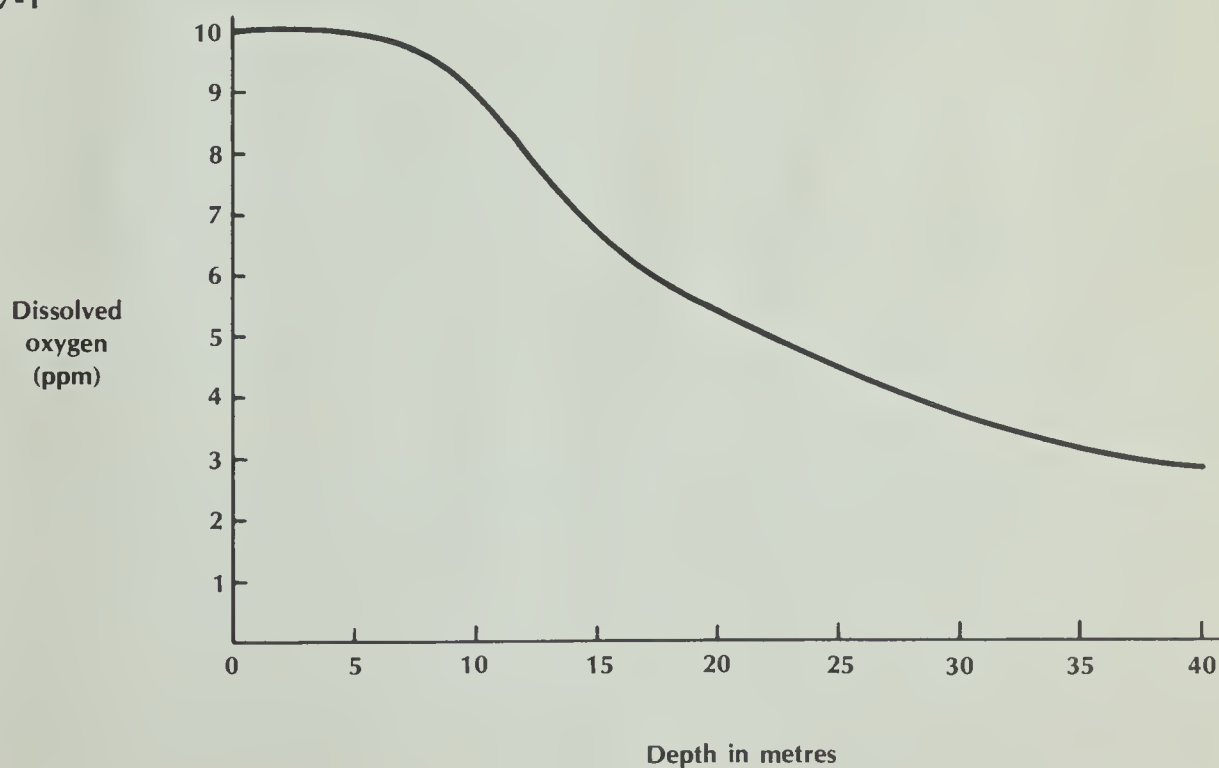
3. Why is oxygen important to organisms living in water? _____

4. (a) Which type of organism (producer or consumer) could provide oxygen to water? _____

(b) What name is given to the process in which oxygen is produced or given off? _____

5. The graph in Figure 77-1 shows the values for dissolved oxygen in a lake at various depths. Does the amount of dissolved oxygen increase or decrease with depth? _____

FIGURE 77-1



6. Considering that the process which gives off oxygen requires light, how might this process be influenced by changes in water depth? _____

7. (a) Which water sample contains more carbon dioxide? _____
(b) Which water sample contains less carbon dioxide? _____
8. A stream having more than 25 ppm carbon dioxide is harmful to most bivalves.
(a) Which of your samples could have come from a stream that could support bivalves? _____

(b) Which samples could not? _____
(c) Explain. _____

9. Carbon dioxide and light are both required for photosynthesis. A shallow pond with many plants growing in it was used as a water source for testing.
(a) How might the amount of carbon dioxide in the pond vary from day to night? _____
(b) Explain. _____

10. When comparing your data in Parts A and B of this experiment to the data of other students in your class, you probably find that your results differ slightly from theirs.
(a) List two places in Part A where errors could be made while doing the procedure. _____

(b) Explain how you could correct these errors. _____

(c) List two places in Part B where errors could be made while doing the procedure. _____

(d) Explain how you could correct these errors. _____

11. Why does a scientist not rely on only one trial when performing an experiment? _____

SOIL CHEMISTRY

78

Soil can be acidic or basic. Soil can limit vegetation growth if it is too acidic or basic. Plants also require several chemical nutrients for proper growth. These nutrients are part of the normal chemical makeup of soil. However, different soils may differ in the amounts of these chemicals. Some soils may be totally lacking certain chemical nutrients. As a result, certain plants may not grow well or may not grow at all in some soils.

In this investigation, you will

- (a) use litmus solution to determine if soil samples are acidic or basic.
- (b) test soil samples to determine how much, if any, calcium, phosphorus, or nitrates are present.

Materials

2 soil samples, A and B
test tubes
droppers—1 for each solution
funnel
filter paper
distilled water
small beakers—2
glass slides—2

spatula
2% litmus solution
hydrochloric acid solution
sodium hydroxide solution
diphenylamine solution
ammonium molybdate solution
tin
ammonium oxalate solution

glass marking pencil (wax)
stoppers—6
graduated cylinder

CAUTION: Chemicals used in this investigation are harmful to skin and clothing. If spillage occurs, rinse with water and call your teacher immediately.

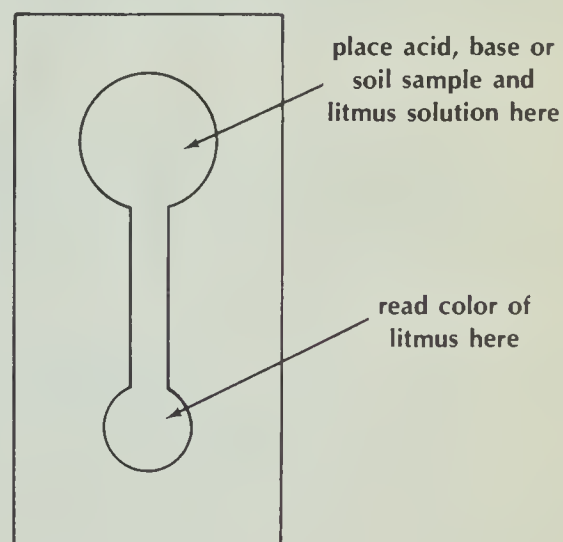
Procedure

Part A. Acid-Base Test

Many substances are classified as being either neutral, acidic, or basic. Pure water is neutral, vinegar is acidic, and soap is basic. Chemically, soils may be either acidic or basic. This chemical quality of a soil may limit or influence the vegetation that grows in it.

- With a glass marking pencil, draw a pattern similar to that shown in Figure 78-1 on each of two clean microscope slides.
- With a dropper, add two drops of hydrochloric acid (a known acid) solution to the large circle of one slide.
- Add two drops of sodium hydroxide (a known base) solution to the large circle of the other slide.
- Add two or three drops of litmus solution to the large circles of each slide.

FIGURE 78-1



- Tip each slide so that the litmus runs slowly down the narrow pencil path toward the small circle.

- Observe the color of the solution on each slide.

- Record the color of the acidic and basic solutions in Table 78-1.

- Rinse off the chemicals from the two slides.

- Add enough soil from sample A to form a small mound in the large circle of one of the slides. Use Figure 78-2 as a guide.

- Form a mound of soil sample B on the large circle of the second slide.

- Add two or three drops of litmus solution to the soil mound on each slide.

- Tip each slide so that the litmus runs slowly down the narrow pencil path toward the small circle.

- Observe the color of the solution on each slide.

- Record the color of the solution from soil samples A and B in Table 78-1.

- Using the color changes on the known acid and base slides, determine and record in Table 78-1 whether each soil sample is acidic or basic.

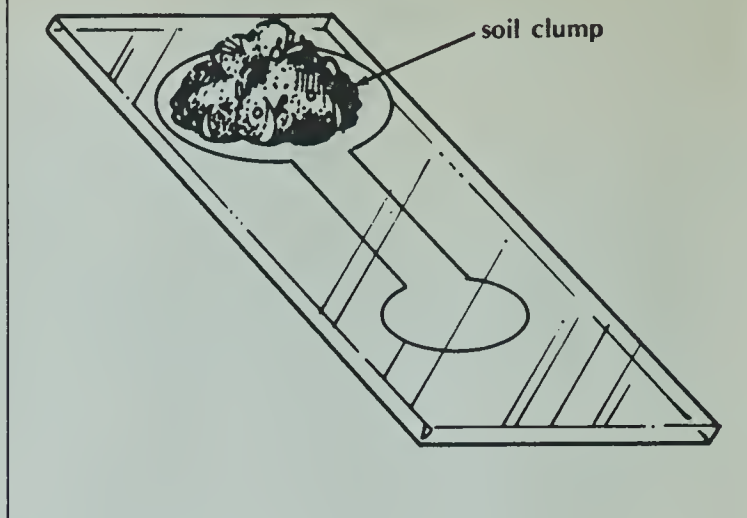
Part B. Nitrate Test

- Place about 5 mL of soil sample A into a clean test tube.

- Add 15 mL of distilled water to the test tube.

- Add a stopper. With your thumb over the stopper, shake the test tube vigorously for one minute.

FIGURE 78-2



- Filter the soil-water mixture through filter paper in a funnel. Collect the clear liquid (called soil extract) in a clean, small beaker (Figure 78-3). Label this beaker "A."

- Repeat the previous four steps using soil sample B. Label the beaker of soil extract "B."

- With separate droppers, add two drops of soil extracts A and B to separate test tubes.

FIGURE 78-3

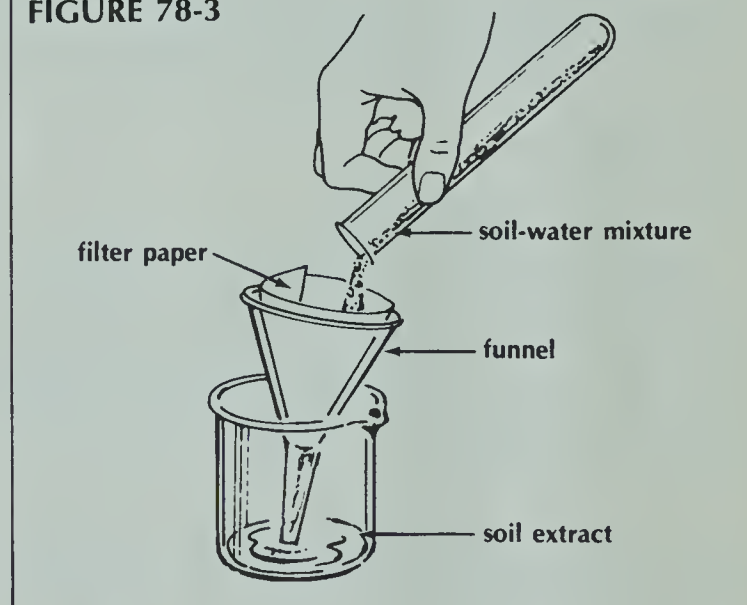


TABLE 78-1. RESULTS OF ACID-BASE TEST

	KNOWN ACID	KNOWN BASE	SOIL SAMPLE A	SOIL SAMPLE B
Color change with litmus				
Is sample acidic or basic?				

- Add two drops of distilled water to a third test tube as a control.
- Add 12 drops of diphenylamine solution to all three test tubes.
- After five minutes, examine each test tube for any color change.

A blue or brown color indicates that adequate nitrates are available in the soil for plant growth. An orange or yellow color indicates that inadequate nitrates are available. No color indicates that no nitrate is present.

- Record the observed color changes in the column "Color observed" of Table 78-2. Indicate if nitrates are "adequate," "inadequate," or "not present" in the column "Amount present."

Part C. Phosphorus Test

- Add 10 drops of soil extracts A and B to separate clean test tubes.
- Add 10 drops of distilled water to a third test tube.
- Add five drops of ammonium molybdate solution to each test tube, stopper, and shake the tubes to mix the contents.
- Drop a small piece of tin into each test tube. Again, stopper and shake the test tubes.
- Examine each test tube for any color change.

A deep blue indicates adequate phosphorus in the soil sample. A pale blue, gray-blue, khaki, or yellow color indicates inadequate phosphorus. No color indicates no phosphorus present.

- Record in Table 78-2 the color changes observed and whether phosphorus is "adequate," "inadequate," or "not present" in each test tube.

Part D. Calcium Test

- Add 30 drops of soil extract A to each of two test tubes.
- Add two drops of ammonium oxalate solution to only *one* of the test tubes.
- Mix the contents of both test tubes by adding a stopper to each and shaking them.
- Hold both test tubes toward the windows or lights.
- Using the untreated test tube of soil extract A as a control, determine whether or not the other solution is cloudy.

A white precipitate (cloudy appearance) appears if calcium is present.

- Record in Table 78-2 whether the test tube with ammonium oxalate added is cloudy or clear. Indicate with "yes" or "no" if calcium is present in sample A.
- Repeat the entire procedure for Part D using soil sample B extract. Prepare two test tubes as before, adding ammonium oxalate solution to one test tube, and using the second test tube as a control.

TABLE 78-2. RESULTS OF NITRATE, PHOSPHORUS, AND CALCIUM TESTS

	NITRATE		PHOSPHORUS		CALCIUM	
Sample	Color Observed	Amount Present	Color Observed	Amount Present	Cloudy or Clear	Present
A						
B						
Water					—	—

Analysis

1. Explain how you can determine whether a soil sample is acidic or basic by using litmus solution. _____
2. (a) Is the litmus solution test qualitative or quantitative? (Qualitative results are descriptive. Quantitative results are numbers.) _____
(b) Explain. _____
3. Many farmers add lime (calcium hydroxide) to their fields prior to planting crops.
(a) Which of the chemicals used in Part A is most similar in name to calcium hydroxide? _____
(b) Often chemical compounds that have similar traits have similar names. Is calcium hydroxide basic or acidic? _____
(c) Potatoes grow well in acidic soil. Would farmers add lime to their potato fields? (NOTE: When an acid is added to a base, the two chemicals cancel each other and the resulting solution is neutral.) _____
(d) Explain. _____
4. Pine needles are known to produce an acidic soil as they accumulate and decay on a forest floor. Explain how this factor may be important in making the floors of evergreen forests bare of vegetation. _____
5. If rainfall is adequate, the amount of plant growth will vary as the amount of nitrates in soil varies.
(a) The formula for nitrate is NO_3^- . What two elements are present in nitrate? _____
(b) What element is present in protein that is not found in fats or carbohydrates? _____
(c) How does a plant get protein? _____
(d) Where does a plant get its supply of nitrate to make protein? _____
6. (a) Was your analysis of soil samples for nitrogen quantitative or qualitative? _____
(b) Explain. _____
7. Phosphorus is present in ATP and in DNA and RNA as phosphates. Thus, growth processes would be slowed down in plants lacking phosphorus.
(a) Which soil sample tested—A or B—would promote more rapid growth of plants? _____
(b) Why? _____
8. Farmers frequently add fertilizers to the soil. What is fertilizer? _____
9. (a) Was the test for calcium qualitative or quantitative? _____
(b) Explain. _____

A SOIL COMMUNITY

79

Does soil contain a community of living organisms? You probably have seen earthworms and insect larvae living in the soil, but what about microorganisms? Are they present in a soil community? You could examine a soil sample under a microscope to find out. However, there are other ways.

Microorganisms give off carbon dioxide during respiration. Therefore, it is possible to test soil samples for the presence of microorganisms indirectly by determining whether or not carbon dioxide is being given off in the soil.

In this investigation, you will

- discover whether microorganisms are present in soil by determining if they have given off carbon dioxide gas.
- measure the amount of carbon dioxide given off.
- determine the amount of carbon dioxide in each sample and draw conclusions.

Materials

soil
water, distilled
phenolphthalein solution
0.01 M sodium hydroxide solution
droppers
large beakers (or milk cartons)—5
spatula

small beakers—5
glucose
graduated cylinder
filter paper
funnels
aluminum foil
glass marking pencil

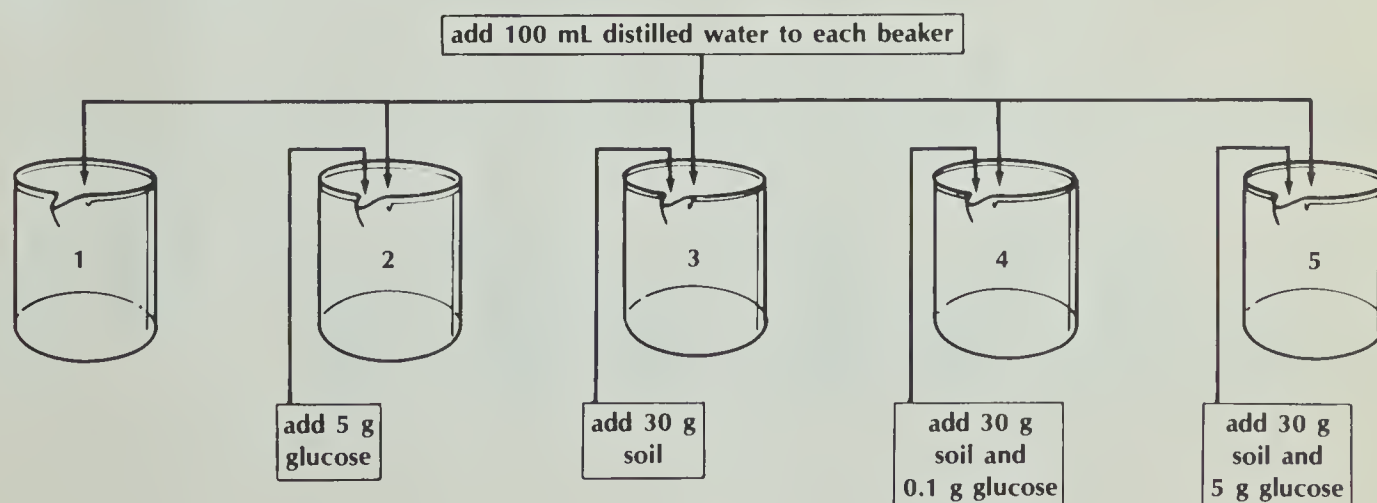
Procedure

Part A. Preparing Soil Samples

- Number five large beakers or empty milk cartons one to five using a glass marking pencil (or masking tape and pen).

Instead of massing out glucose and soil, you can approximate their amounts. For example, 30 g of soil is about 10 mL, 5 g of glucose is about 5 mL, and 0.1 g of glucose is about a pinch.

FIGURE 79-1

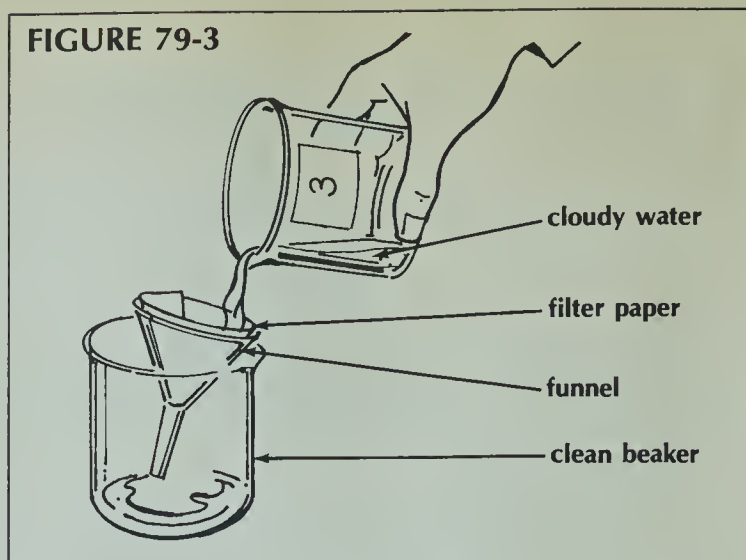


- Prepare the beakers as shown in Figure 79-1.
- Stir the contents of each beaker.
- Cover each beaker with aluminum foil.
- Allow the beakers to sit for 24 or 48 hours.

Part B. Analysis of Soil Water for CO₂ Content

- Number five small beakers one to five.
- Pour water from each large beaker only into its corresponding small beaker. Fill each small beaker to the same height to provide an equal volume in each. Use Figure 79-2 as a guide.
- If the water from any of the small beakers is cloudy, filter it as shown in Figure 79-3.
- With a dropper, add three drops of phenolphthalein solution to each water sample.
- Add 0.01 M sodium hydroxide solution a drop at a time to each water sample. **CAUTION:** *Sodium hydroxide is harmful to skin and clothing. Rinse with water if spillage occurs and call your teacher.*
- Gently swirl the beakers after the addition of each drop of sodium hydroxide solution.
- Add and count the number of drops of sodium hydroxide solution needed to obtain a permanent light pink color.
- Match the light pink color of beakers two to five to the color in beaker one.

FIGURE 79-3



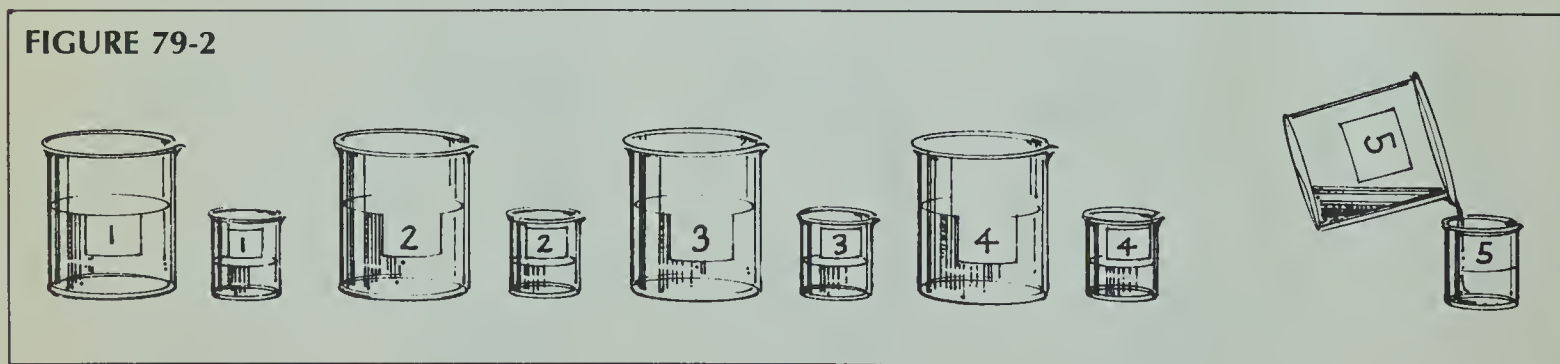
- Record in Table 79-1 the number of drops of 0.01 M sodium hydroxide solution needed to cause the color change.

The number of drops of sodium hydroxide added to each beaker is almost equal to the amount of carbon dioxide in the water.

TABLE 79-1. NUMBER OF DROPS OF SODIUM HYDROXIDE ADDED TO SOIL

BEAKER	NUMBER OF DROPS
1	
2	
3	
4	
5	

FIGURE 79-2



Analysis

1. Explain how you tested for the presence of carbon dioxide in this experiment. _____

2. (a) What is present in a soil community that can produce carbon dioxide? _____
(b) What process is mainly responsible for the production of this gas? _____
3. (a) Which beaker(s) required the smallest number of drops of sodium hydroxide solution? _____
(b) Which beaker(s) produced the smallest amount of carbon dioxide? _____
4. (a) Which beaker required the largest number of drops of sodium hydroxide solution? _____
(b) Which beaker produced the largest amount of carbon dioxide? _____
5. (a) What was originally added to beaker 1? _____
(b) Did you expect any carbon dioxide to be produced in beaker 1? _____
(c) What was the purpose of setting up beaker 1 since you could predict its results? (What did beaker 1 show?) _____

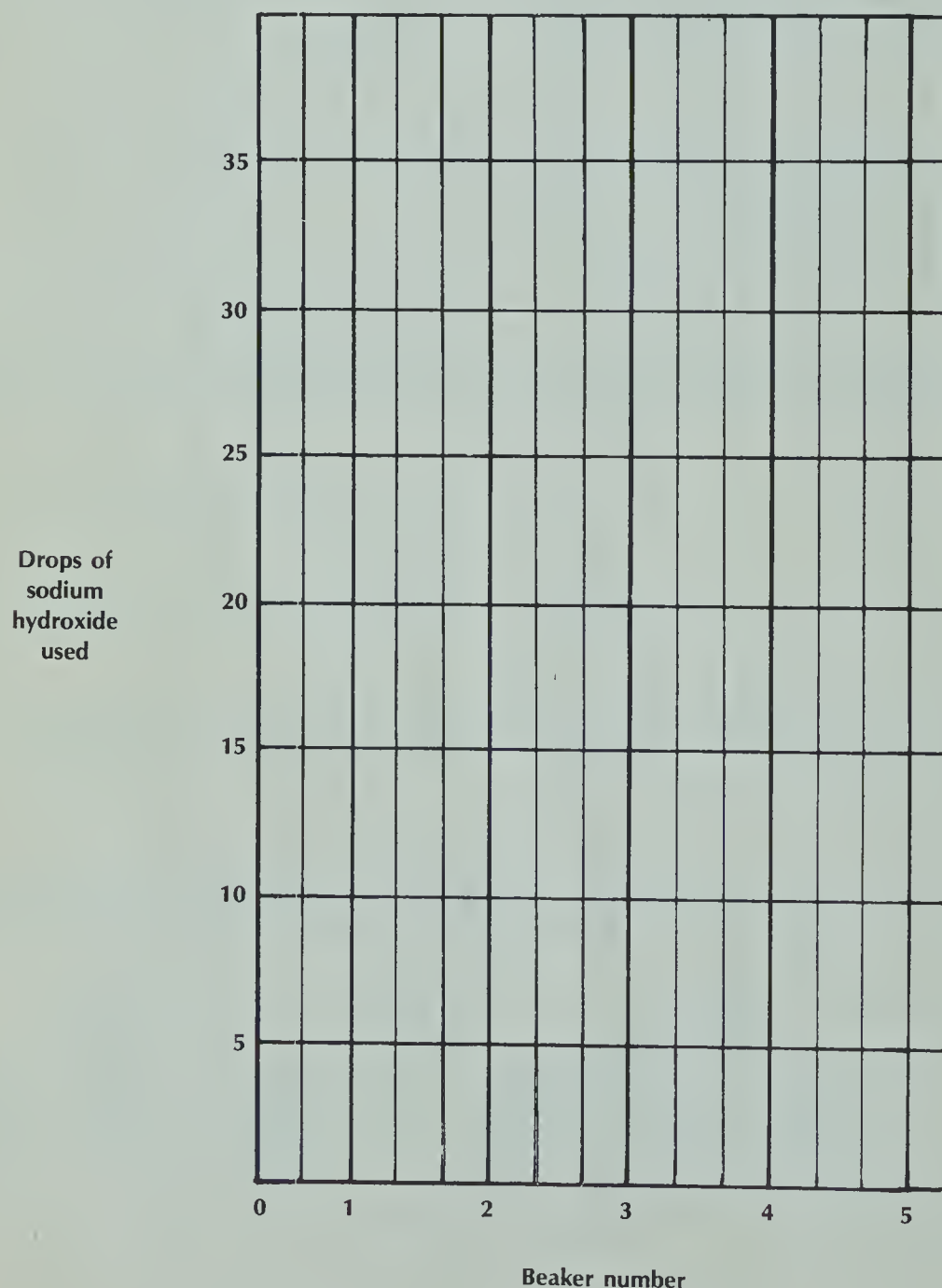
6. How does the amount of carbon dioxide produced by beaker 3 compare with the amounts produced by beakers 4 and 5? _____

7. Explain the role of sugar in carbon dioxide production. (Hint: Microorganisms use glucose for the same process humans do.) _____

8. What experimental evidence do you have that sugar and water alone are not responsible for carbon dioxide production?_____

9. Defend or argue against the following statement and explain why. "Soil contains a living community."_____

10. Prepare a bar graph of your data from Table 79-1 in the space provided below. Shade in the number of drops of sodium hydroxide opposite each beaker.



MICROCOMMUNITIES

80

Usually when a community and the organisms associated with it are described, observable (macro-) organisms such as trees, grass, pigeons, and squirrels are listed. However, a community also has many microorganisms. Microorganisms can make up their own microcommunities. These microcommunities are small and inconspicuous. With a microscope, you can examine communities which would ordinarily go undetected. It is also possible to identify and classify many of the organisms found in microcommunities.

In this investigation, you will

- examine the microcommunity in bean water and in pond water.
- identify the organisms found in these two microcommunities.
- determine if each organism is motile or sessile (moves about or does not move about).
- determine if each organism is a producer or a consumer (is green or not green).

Materials

bean water (tap water in which beans
have soaked for several days)

pond water

dropper

microscope

glass slide

coverslip

Bunsen burner

water

small beaker

crystal violet stain

graduated cylinder

filter paper

funnel

Procedure

Part A. Bean-Water Microcommunity

- Place a drop of bean water on a microscope slide, spreading it into a thin film the size of a nickel.

- Quickly pass the slide with the bean-water film through a Bunsen burner flame several times.

CAUTION: Always be careful around open flames. Secure loose hair and clothing away from flame. Warm until the bean water has dried on the slide. This process is called "fixing." Fixing sticks the cells to the slide. Use Figure 80-1A as a guide.

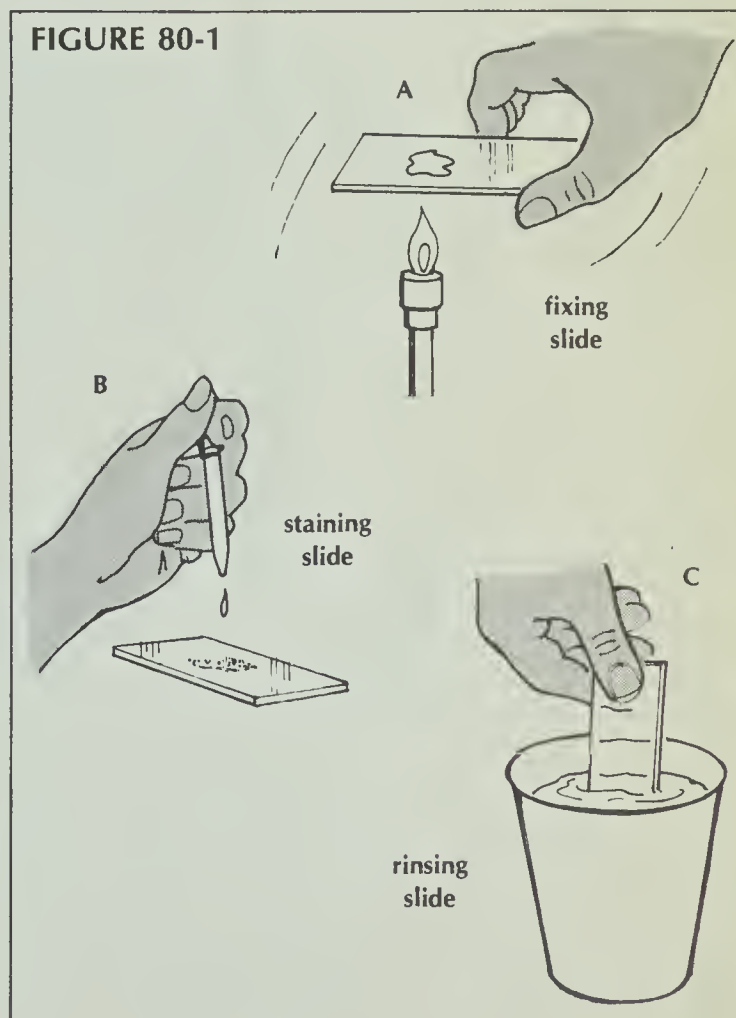
- Add several drops of crystal violet stain to the dried bean-water film. Staining the slide will make microorganisms on the slide easier to see. Use Figure 80-1B as a guide.

- After one minute, rinse the stain off with water. This rinsing is best done by dipping the slide into a beaker or paper cup filled with water. Use Figure 80-1C as a guide.

- Allow your slide to air dry.

- After the slide has dried, examine the bean-water microcommunity under high power of your microscope. (No coverslip is needed.)

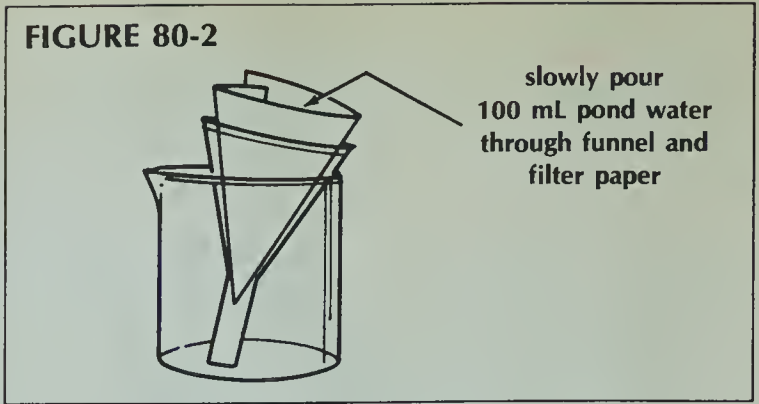
FIGURE 80-1



- Prepare a wet mount of bean water. (This time a coverslip is needed.)
- Examine the wet mount under high power of your microscope.
- Using the diagrams in Figure 80-3 for comparison, identify the organisms in your bean-water microcommunity. Note particularly the shapes of the organisms to aid in your identifications.
- By examining a wet mount, determine whether each organism is motile or is sessile. Record your findings in Table 80-1.
- By examining the wet mount, determine whether each organism is a producer or a consumer. Producers usually will contain colored pigments ranging from yellow to green to blue-green. Consumers usually are colorless. Record your findings in Table 80-1.
- Record in Table 80-1 the names of the organisms observed in the bean-water microcommunity.

Part B. Pond-Water Microcommunity

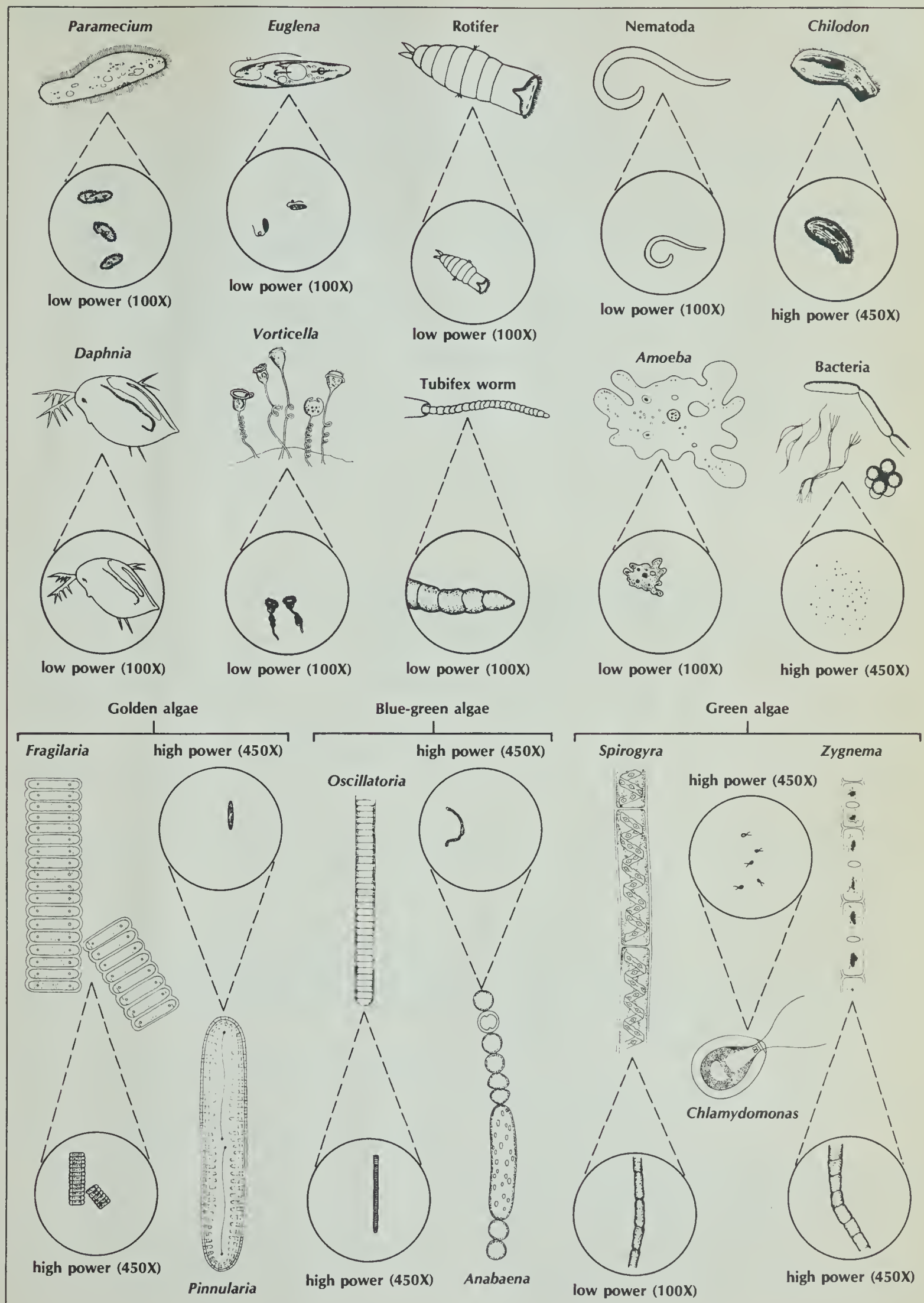
- Prepare a funnel with filter paper.
- Filter 100 mL of pond water using Figure 80-2 as a guide. This procedure will concentrate any organisms present in the water and make them easier to find.



- Remove the filter paper from the funnel after the last of the pond water has drained through.
- Turn the filter paper inside out and touch the moist end which used to be the tip of the paper cone to a glass slide.
- Add a coverslip to the slide and observe this wet mount under low and high powers.
- Using the diagrams in Figure 80-3 for comparison, identify the organisms in your pond-water microcommunity.
- Record in Table 80-1 the names of the organisms observed in the pond water microcommunity.
- Determine and record in Table 80-1 whether each organism is motile or sessile.
- Determine and record in Table 80-1 whether each organism is a producer or a consumer.

TABLE 80-1. ORGANISMS IN MICROCOMMUNITIES			
NAME OF ORGANISM	COMMUNITY (BEAN WATER OR POND WATER)	MOTILE OR SESSILE	PRODUCER OR CONSUMER

FIGURE 80-3



Analysis

1. Explain why it is necessary to stain the organisms in the bean-water microcommunity. _____

2. List several possible sources of the organisms in the bean water. _____

3. (a) Do you think most of the microorganisms in bean water are producers or consumers? _____
(b) What evidence do you have that may support your answer? _____

4. Explain the color difference between producers and consumers in pond-water microcommunities.

5. (a) Did you find a relationship between motility and whether an organism is a consumer or a producer? _____
(b) Explain. _____

6. Producer organisms carry on photosynthesis when light is available. They also carry on respiration all the time but at a slower rate than photosynthesis.
 - (a) During times when light is available, which gas is given off in large amounts by producers?

 - (b) Which gas is given off in small amounts by producers during light conditions? _____

 - (c) Which gas is given off in small amounts by producers during dark conditions? _____
 - (d) During times when light is available, which gas is used in a community in large amounts by producers? _____

 - (e) Which gas is used in small amounts by producers during light conditions? _____
 - (f) Which gas is used in small amounts by producers during dark conditions? _____
 - (g) Describe the major contribution made by producers in a community with regard to gas exchange. _____

7. What other major contribution is made by producers to communities? _____

THERMAL POLLUTION

81

Thermal pollution is the pollution of water by heating. Why is there concern about thermal pollution? What difference does it make if humans change the temperature of bodies of water? How is this change harmful to organisms living in the water? Why we should be concerned about thermal pollution can be understood partly by determining the amount of dissolved oxygen in water at various temperatures.

In this investigation, you will

- follow the laboratory technique used in Investigation 77 for measuring the amount of dissolved oxygen in water.
- determine the ppm (parts per million) of dissolved oxygen in samples of warm and cold water.
- relate your results to the possible effect of thermal pollution on organisms living in water.

Materials

metric ruler
hot water sample
cold water sample
thermometer (Celsius scale)
droppers (1 for each solution)
small flasks (or beakers)—2
labels

solution A—48% manganous sulfate
solution B—70% potassium hydroxide and
15% potassium iodide
solution C—concentrated sulfuric acid
solution D—2% starch
solution E—0.31% sodium thiosulfate

CAUTION: *All chemicals used are harmful to skin and clothing. Rinse with water if spillage occurs and call your teacher immediately.*

Procedure

- Obtain 100 mL of each water sample for chemical analysis.
- Place the water samples in small flasks or beakers. Be careful to avoid bubbling (aerating) the water while pouring from the original container to the flasks.
- With a thermometer, determine the temperature of each water sample.
- Record the temperatures in Table 81-1 using the row marked "Trial 1."
- Label the flasks "cold" and "hot."
- With a dropper, add 10 drops of solution A to each water sample. Hold the dropper close to the water surface to avoid splashing.
- Add 10 drops of solution B to each water sample.
- Gently swirl each flask. Be careful to avoid forming bubbles.
- Let the flasks stand for one minute. (If using seawater as a sample, it must stand for 15 minutes.)
- With a dropper, add 15 drops of solution C to each water sample. Gently mix the contents by swirling the flasks.
- With a dropper, add 5 drops of solution D to each sample and gently swirl. A deep blue color should appear after the flasks are swirled.
- With a dropper, add solution E one drop at a time to each sample. Continue to add and count the

number of drops until the water sample becomes colorless. Swirl the water sample after every few drops in order to determine the true color of the solution.

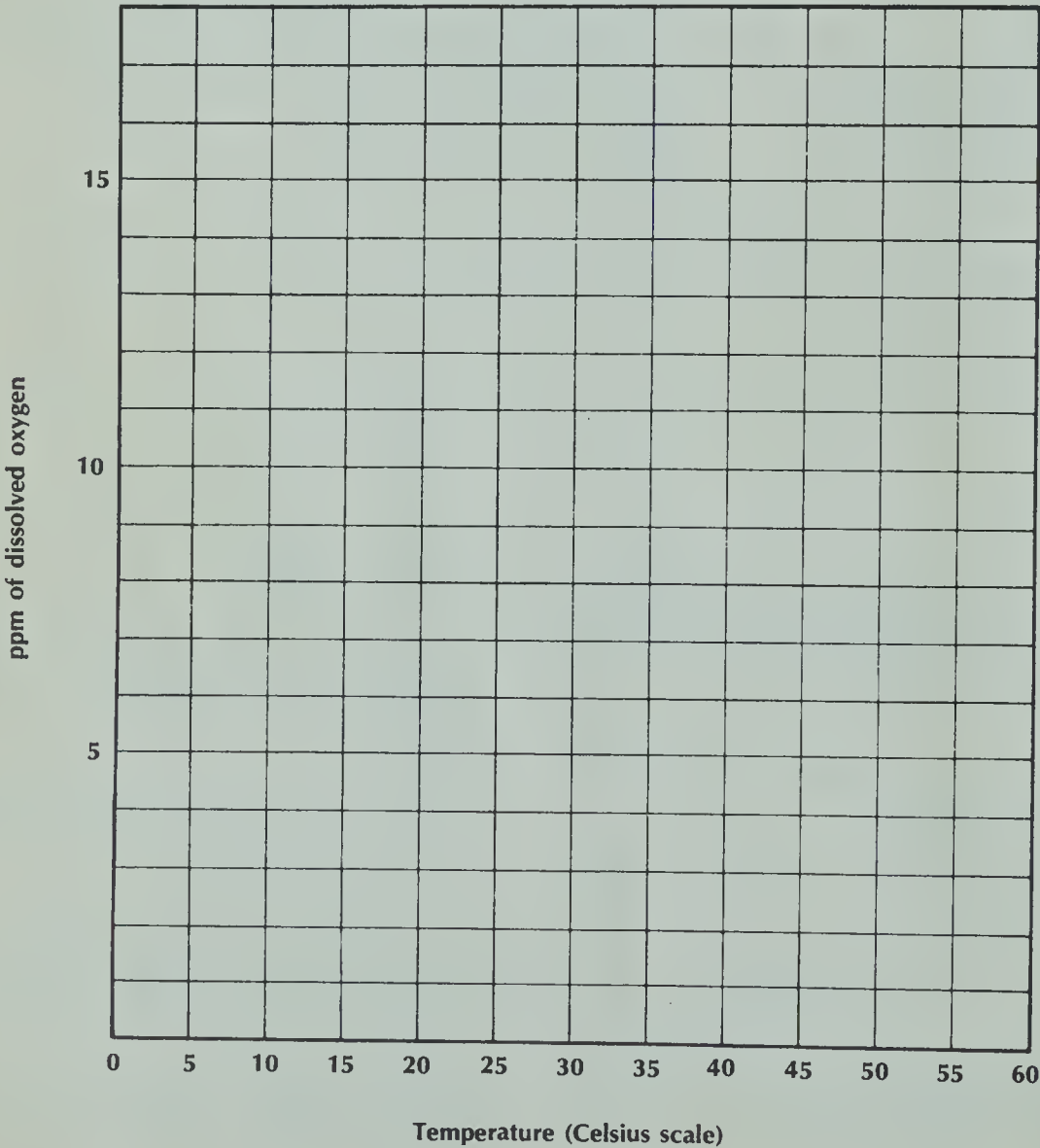
- Record in Table 81-1 the number of drops of solution E needed to return each water sample to colorless.
- Convert the number of drops of solution E added to ppm (parts per million) of dissolved oxygen. Do

this by dividing the number of drops of solution E by 20. Record the ppm in Table 81-1.

- Perform a second trial on new samples of both waters. Record your data in Table 81-1 using the row marked "Trial 2."
- Determine the average temperature, drops of solution E and ppm of dissolved oxygen for both cold and hot water samples. Record the averages in Table 81-1.

TABLE 81-1. RESULTS OF TESTS ON WATER SAMPLES						
	COLD WATER			HOT WATER		
Trial	Temperature	Number of Drops of Solution E	PPM Dissolved O ₂	Temperature	Number of Drops of Solution E	PPM Dissolved O ₂
1						
2						
Averages						

FIGURE 81-1



Analysis

1. Based on your results,

(a) which water temperature has the most dissolved oxygen? _____

(b) which water temperature has the least dissolved oxygen? _____

2. A scientist performing this same experiment arrived at these results:

0° C = 14.2 ppm oxygen

10°C = 10.8 ppm oxygen

30° C = 7.4 ppm oxygen

50° C = 5.5 ppm oxygen

Plot these values on the graph marked Figure 81-1. Connect the four points with a line. Label the line "scientist's results."

3. Plot your results on the same graph. (Use average values.) Connect the two points with a line and label the line "my results."

4. Using the scientist's results, describe how the ppm of dissolved oxygen changes as water temperature goes up. _____

5. (a) Using your results, describe how the ppm of dissolved oxygen changes as water temperature goes up. _____

(b) Compare your results to the scientist's results. _____

6. Organisms living in water require dissolved oxygen for respiration. Certain fish, for example, cannot live in water with less than 5 ppm of dissolved oxygen. What would happen to

(a) the amount of dissolved oxygen in a body of water if the water were suddenly heated by thermal pollution? _____

(b) fish living in that body of water? _____

7. Small ponds will often heat up during the late summer. Many dead fish are seen floating on its surface at this time of year. Explain. _____

8. Fish usually can survive during the winter when ponds or lakes form a layer of ice over their surface. Explain how the fish can survive when no gas exchange is occurring with the atmosphere. _____

9. Figure 81-2 is a graph that shows how much oxygen a fresh water sample can hold at a certain temperature. Place the edge of a ruler so that the ruler connects a temperature reading and the 100% saturation point. Read the amount of dissolved oxygen where the ruler edge crosses the bottom line. For example, at 5°C and 100% saturation, water can hold a maximum of 13 ppm of oxygen. How much dissolved oxygen can water hold at

(a) 10°C and 100% saturation? _____

(b) 20°C and 100% saturation? _____

10. The graph can also supply you with some other information. At a certain temperature, the amount of dissolved oxygen may be less than 100%. If this situation occurs, the water is not saturated with oxygen. In other words, the water could hold more oxygen than is actually present. The amount of oxygen in water compared to how much it can hold at a certain temperature is called its percent (%) saturation. For example, at 10°C, one sample of water holds 4.3 ppm of oxygen. Its percent saturation is 50. Line up your ruler edge with the temperature of 10°C and 5.6 ppm of oxygen. Read the percent saturation off the slanted line.

What is the percent saturation of a water sample at

(a) 15°C with 4 ppm oxygen? _____

How much more O₂ could the water hold? _____

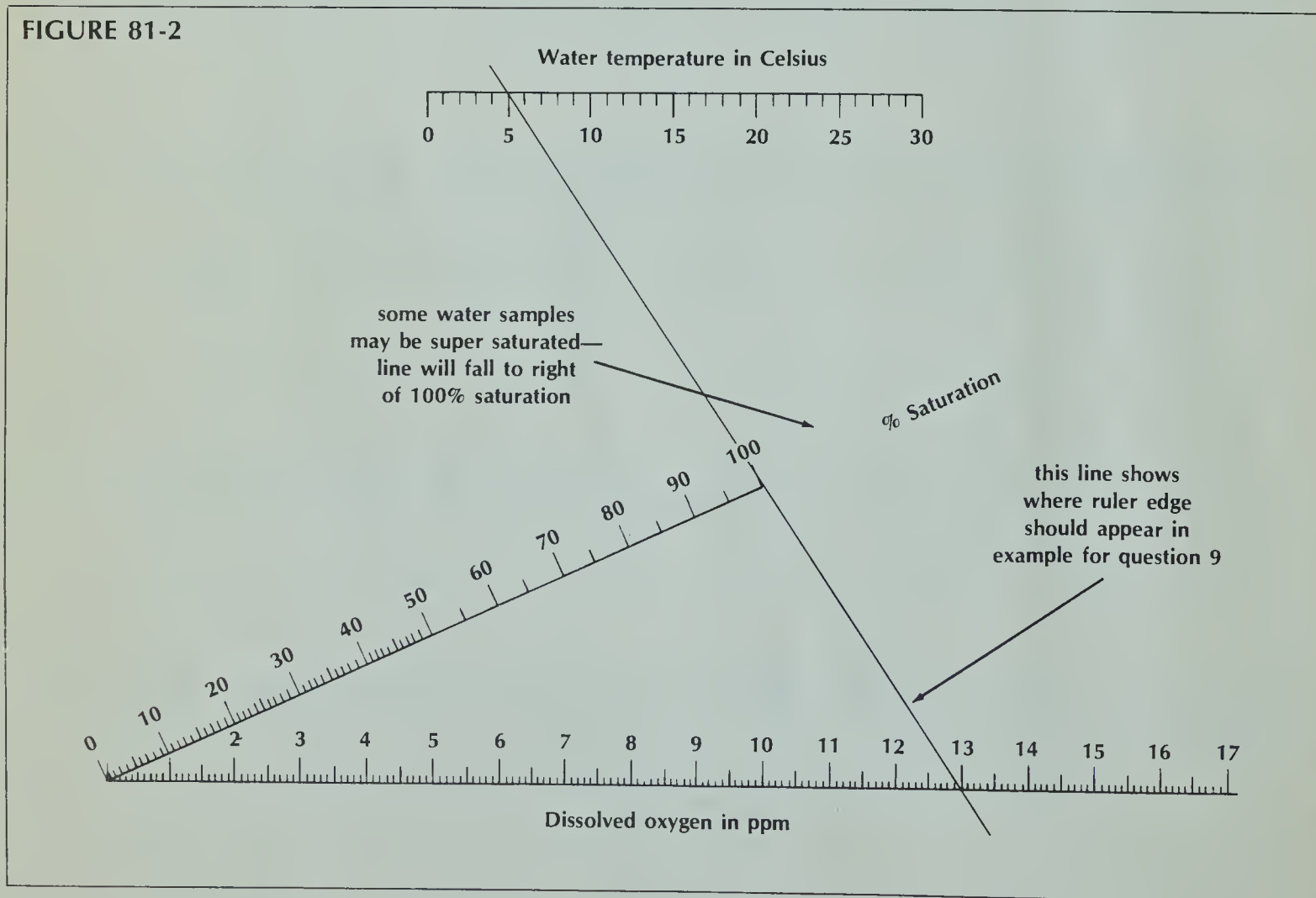
(b) 8°C with 10 ppm oxygen? _____

How much more O₂ could the water hold? _____

What is the percent saturation of your

(c) cold water sample? (NOTE: Use Trial 1 data.) _____

FIGURE 81-2



ACID RAIN

82

We would like to think of rain or snow as pure, clean, neutral water. However, rain or snow falling over much of the United States, Canada, and Europe is acidic. Water vapor in the air mixes with chemicals such as sulfur dioxide and nitrogen oxides, forming weak acids. These chemicals are present in the atmosphere as a result of the burning of fossil fuels such as oil, coal, and gasoline. Acid rain has already caused a number of small lakes and ponds to become acidic. Fish, insects, and amphibians that normally live in these lakes and ponds are dying because they cannot live in this acidic water. Acid rain caused by humans is a serious problem to our environment.

In this investigation, you will

- (a) learn how to read a chemical chart called the pH scale. This scale identifies liquids as acids, bases, or neutral.
- (b) use pH paper and the pH scale to determine if a variety of liquids including rainwater are acids, bases, or neutral.
- (c) draw isolines to show where acidic rain is falling on different areas of North America.

Materials

small strips of pH paper (2 cm long)—10
tweezers
pH paper color chart
rain (or snow) samples collected at
different times—3

7 small beakers marked and filled with:
(a) lemon juice (e) vinegar
(b) lye in water (f) tap water
(c) distilled water (g) baking soda in water
(d) sea water

Procedure

Part A. Using the pH Scale

A liquid may be an acid, base or neutral. Pure water is neutral, meaning it is neither an acid nor a base. Vinegar is an acidic liquid. Liquids such as lye, drain cleaner, and detergents are bases.

The degree of acidity or basicity can be judged by using a table called the pH scale. Neutral liquids are at the mid-point on the scale (#7). Acids have values below seven, and bases have values above seven.

Use Figure 82-1 as a guide when answering these questions.

1. (a) What is the pH of distilled water? _____
(b) Is distilled water an acid, base, or neutral?

2. (a) What is the pH of sea water? _____

(b) Is it an acid, a base, or neutral? _____

3. (a) What is the pH of lemon juice? _____

(b) Is it an acid, a base, or neutral? _____

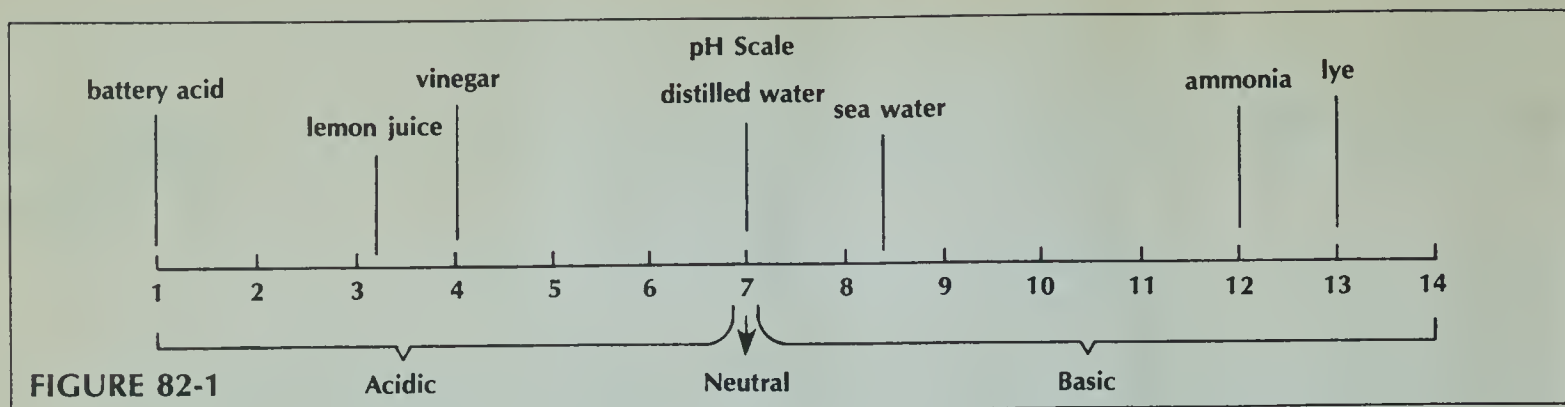
As the numbers on the pH scale go from seven down to one, liquids become more acidic. Sometimes the numbers on the pH scale can be read in decimals.

4. (a) Which is more acidic, a liquid with a pH of

6.7, or one with a pH of 4? _____

(b) Which is more acidic, battery acid or vinegar? _____

As the numbers go from 7 to 14, liquids become more basic.



5. (a) Which liquid is more basic, one with a pH of 8.5, or one with a pH of 10?_____

(b) Which is more basic, ammonia or lye?____

Part B. Using pH Paper to Test Liquids

The pH of liquids can be determined by using a chemically treated paper called pH paper. When touched to a liquid, pH paper changes color. By using a color chart, you can determine the pH of the tested liquid by the color of the pH paper.

- Test the pH of liquids using the following steps.

CAUTION: *Chemicals used are harmful to skin and clothing. Rinse with water if spillage occurs and call your teacher immediately.*

- *Step 1.* Hold a small piece of pH paper with tweezers.

- *Step 2.* Dip the pH paper into the liquid and then remove it. DO NOT dip the tweezers themselves into the liquid. If tweezers get dipped, rinse them in tap water and dry them.

- *Step 3.* Match the color of the pH paper to the color chart. Note the corresponding pH number.

- *Step 4.* Discard the pH paper. Use a new piece of pH paper for each new test.

- Test the liquids listed in Table 82-1.

- Record your data in Table 82-1.

- Complete Table 82-1 by filling in the last column.

Part C. Testing the pH of Rain or Melted Snow

- Obtain two or three samples of rainwater.

- Note and record the collection dates for each sample in Table 82-2.

- Test and record the pH of each sample in Table 82-2. Decide if each sample is an acid, base, or neutral.

Part D. Mapping Areas With Acid Rain

The map in Figure 82-2 is to be completed during this part of the experiment. Lines connecting numbers which are the same are called isolines (iso- means same). The isolines on this map connect areas having rainfall with the same pH.

TABLE 82-1. pH TESTS OF KNOWN LIQUIDS

LIQUID	pH	ACID, BASE, OR NEUTRAL
Tap water		
Lye in water		
Lemon juice		
Distilled water		
Sea water		
Vinegar		
Baking soda		

● Note the two isolines which have been drawn for you. One isoline connects areas that have rainfall with a pH of 6.5. The second isoline connects areas that have rainfall with a pH of 6.0. Notice that these lines are smooth and continuous. Notice also that these lines DO NOT cross each other. Observe that all the pH's on one side of the 6.0 pH line are higher than 6.0, and all numbers on the other side of the line have pH's of less than 6.0.

● Draw the isoline for areas having rainfall with a pH of 5.5. All numbers on one side of this line should be higher than 5.5, and all numbers on the other side of this line should be lower than 5.5.

● Draw the rest of the isolines for areas having rainfalls with a pH of 5.0, 4.6, 4.4, 4.3, and 4.2.

TABLE 82-2. TESTING OF RAIN SAMPLES			
SAMPLE	DATE COLLECTED	pH	ACID, BASE, OR NEUTRAL
1			
2			
3			

Analysis

1. (a) How is acid rain formed? _____

(b) Why is acid rain an ecological problem? _____

(c) Is acid rain the result of human influence? _____ Explain. _____

2. (a) Using the map in Part D, determine the expected pH of rainfall in the area where you live.

(b) What were the pH values of the rain samples you tested? _____

(c) Were they close to the pH values predicted by the map? _____

(d) List some reasons pH values of samples might differ from predicted values. _____

3. (a) What seems to be the trend in pH of rainfall as one travels from west to east in North America?

(b) Why might this trend occur? (NOTE: Winds generally blow from west to east across North America.) _____

4. At a pH of 6.0, mussels in a lake or stream begin to die. At a pH of 5.5 and 5.0, bass and trout are killed.

How might the death of these animals affect the ecology of a lake or stream in general? _____

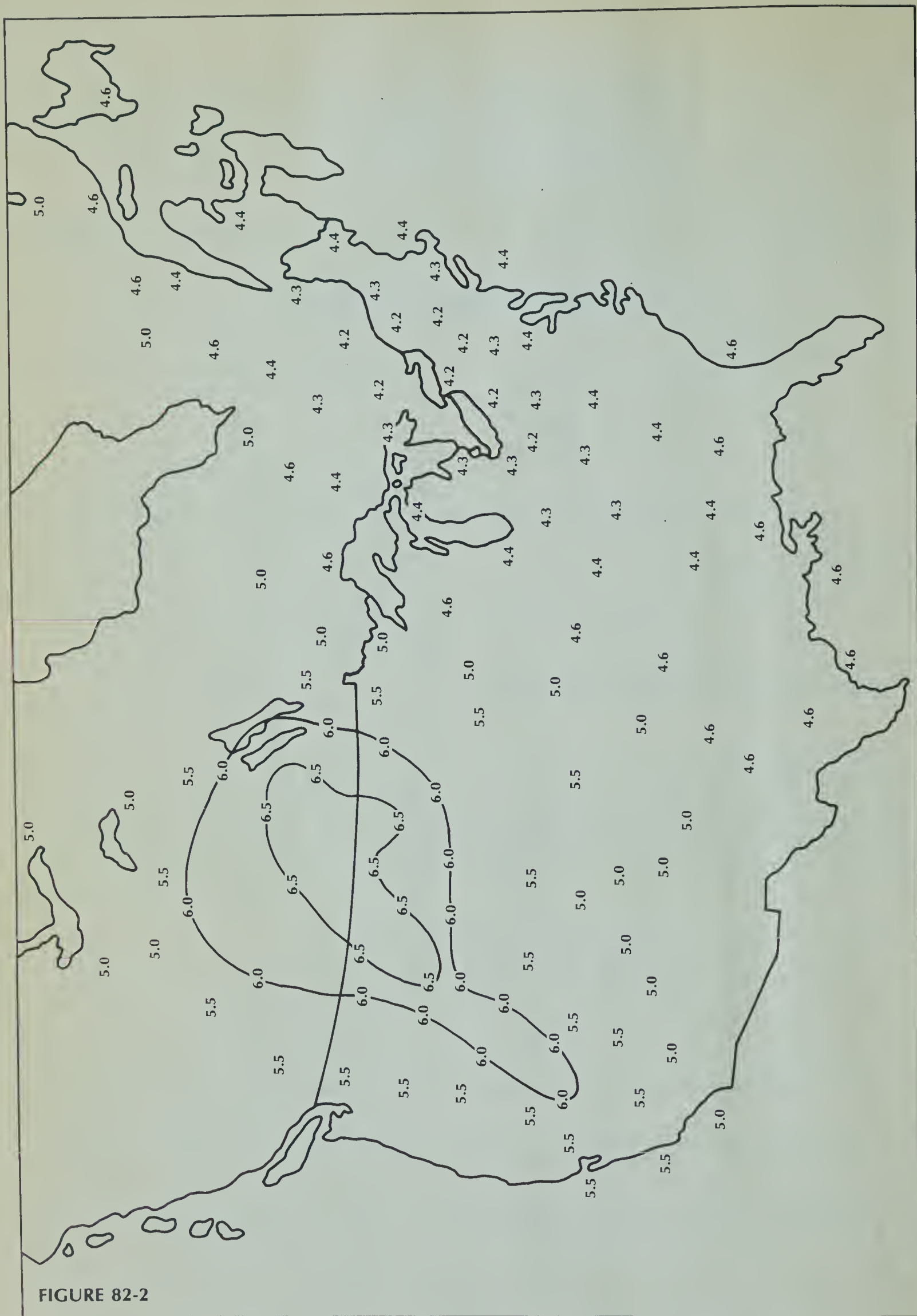


FIGURE 82-2

GLOSSARY

Pronunciation Key

a. .back (BAK)	i (i + con + e). .idea, life (i DEE uh, LIFE)	sh. .shelf (SHELF)
er. .care, fair (KER, FER)	oh. .go (GOH)	ch. .nature (NAY chur)
ay. .day (DAY)	aw. .soft (SAWFT)	g. .gift (GIHFT)
ah. .father (FAHTH ur)	or. .orbit (OR but)	j. .gem, edge (JEM, EJ)
ar. .car (KAR)	oy. .coin (KOYN)	ing. .sing (SING)
ow. .flower, loud (FLOW ur, LOWD)	oo. .foot (FOOT)	zh. .vision (VIHZH un)
e. .less (LES)	yoo. .pure (PYOOR)	k. .cake (KAYK)
ee. .leaf (LEEF)	ew. .food (FEWD)	s. .seed, cent (SEED, SENT)
ih. .trip (TRIHP)	yew. .few (FYEW)	z. .zone, raise (ZOHN, RAYZ)
	uh (u + con). .comma, mother (KAHM uh, MUTH ur)	

acid: substance which in solution has a greater concentration of hydrogen ions than hydroxide ions

acid rain: rain with a low pH

adaptation: trait that makes an organism better able to survive in its surroundings

adenine (AD un een): molecule which, along with ribose and phosphate groups, makes up ATP

adenosine diphosphate (uh DEN uh seen • di FAHS fayt) (ADP): compound changed by glucose into ATP in order to be used as an energy source for cells

adenosine triphosphate (uh DEN un seen • tri FAHS fayt) (ATP): source of chemical energy used by cells for biological work

adventitious (ad ven TIHSH us) **roots:** roots which grow from the stems of plants allowing them to be vegetatively propagated

agar: substance made from brown algae used to make culture media gel (nutrient agar)

albumen: "white" of egg; composed of protein

allele (uh LEEL): dominant or recessive form which a gene may take

all or none response: a muscle fiber contracts fully or does not contract at all; a neuron either carries an impulse or it does not

alternation of generations: life cycle in plants and plant-like protists in which diploid and monoploid generations follow each other

amino (uh MEE noh) **acid:** molecule containing nitrogen that joins with other amino acids to make up proteins

amino group: special arrangement of hydrogen and nitrogen atoms found in amino acids

ampulla: bulb-shaped structure in the water vascular system of a starfish

anaphase (AN uh fayz): phase of mitosis in which one strand of each chromosome is pulled to each pole of the cell

angiosperms (AN jee uh spermz): flowering plants

antagonistic: working in opposition to something else

anterior (AN THIR ee ur): front part of an animal

anther (AN thur): male sporangium at the tip of the stamens

antheridium (an thuh RIHD ee um): male sex organ in bryophytes and ferns

antibiotic: drug which cures certain bacterial diseases

anticodon: set of three bases at one end of tRNA; fits only with certain condons of mRNA

anus (AY nus): an opening to the large intestine from which undigested foods are expelled

apical (AY pih kul) **meristem:** plant growth tissue located at the tips of roots and stems

archegonium (ar kih GOH nee um): female sex organ in bryophytes and ferns

artery: vessel which carries blood away from the heart

ascus: spore producing structure of some fungi

asexual (ay SEK shul) **reproduction:** forming offspring without combining eggs and sperm

ATP: see adenosine triphosphate

autotroph (AWT uh trohf): organism which produces its own food

auricle: chamber of heart that receives blood from veins; "ear" of a planarian

auxin (AWK sun): plant hormone

bark: outside covering of a woody stem

base: substance which in solution has a greater concentration of hydroxide ions than hydrogen ions; compound containing nitrogen which makes up part of a nucleic acid

behavior: responses made by an organism to the stimuli in its environment

Benedict's test: test used to determine if a substance is a monosaccharide

biological key: a listing of specific characteristics, such as structure and behavior, in such a way that an organism can be identified

blood: liquid tissue in an organism that carries oxygen and carbon dioxide

blood pressure: pressure exerted by blood on the walls of blood vessels

bromthymol blue: chemical indicator that detects the presence of carbon dioxide gas

broth culture: a tube containing an organism in a liquid medium

brown paper test: test used to identify fats

capillary: smallest kind of blood vessel; connects arteries and veins

carbohydrate: chemical compound found in cells used as an energy source or in making cell structures

carboxyl (kar BAHK sul) **group:** special arrangement of oxygen, carbon, and hydrogen atoms found in amino acids and other complex molecules

cardiac (KARD ee ak) **muscle:** muscle of the heart

cell: smallest living unit of which all organisms are composed

cell division: process in which one cell becomes two; mitosis

cell membrane: thin outer boundary which surrounds a cell and separates it from neighboring cells and the environment

cellular respiration: process by which food is turned into energy

cell wall: cell part found in plants and some protists; composed of cellulose and other carbohydrates; functions in support

centromere (SEN truh mihr): narrow place on the chromosome where chromatids are joined

chemical formula: combinations of symbols which represent the number and kind of each atom in a compound

chemical indicator: substance used to detect the presence or absence of certain other substances

chlorophyll: green pigment which is essential for the conversion of light energy to chemical energy in autotrophic organisms

chloroplast (KLOR uh plast): organelle found in most producers which contains chlorophyll

chromatid (KROH muh tid): individual strand in a double-stranded chromosome

chromosome (KROH muh sohm): part inside the nucleus which carries information that determines the traits that living things have

chromatogram: the pattern formed on absorbent paper as different compounds are absorbed and separated

cilia (SIHL ee uh): tiny hairlike projections used for locomotion in some one-celled organisms

circulatory (SUR kyuh luh tor ee) **system:** system made up of the blood and the structures through which it moves

class: largest division of a phylum

classification: the process of separating a large group of closely related organisms into smaller subgroups

codon (KOH dohn): sequence of three bases representing a certain amino acid

community: producers, consumers, and decomposers living together in an area and affecting each other

concentration: the number of molecules of a substance present per unit of volume

conductive tissue: tissue in plants which transports food, water, and minerals

cone: seed-bearing or pollen-bearing structure of gymnosperms

consumer: living thing that eats other organisms

corpus luteum (KOR pus • LEWT ee um): yellow tissue that forms from the ruptured follicle

corpus luteum stage: stage in the menstrual cycle during which the corpus luteum produces progesterone to maintain the uterus for pregnancy

cortex cells: large, loosely packed cells that store food in a plant

cotyledon (kaht ul EED un): seed leaf; stores food for the embryo

cutin: waxy material covering the epidermis of a leaf that helps prevent water loss

cytoplasm (SITE uh plaz um): jellylike inner portion of the cell

cytosine (SITE uh seen): one of the bases in the nucleic acids

daughter cells: two cells formed as the result of mitosis of a single cell

death rate: number of organisms that die in a given period of time

decomposer: organisms such as bacteria or fungi which causes decay

deoxyribonucleic (dee AHK sih ri boh noo klay ihk) **acid (DNA):** complex molecule which makes up genes; composed of deoxyribose, phosphoric acid, and one of four bases—cytosine, thymine, guanine, and adenine

depth of field: the layer of a slide or wet mount in which a microscope is focused

development: series of changes a living thing undergoes in attaining its final form

diameter: distance across the exact center of a circle

diaphragm: part of a microscope that allows differing amounts of light; sheetlike muscle that separates the chest from the abdomen; important in breathing

diastole (di AS tuh lee): short period of "rest" after the heart contracts

dicot (DI kaht): plant whose seeds contain two cotyledons

diffusion (dihf YEW zhun): the movement of molecules from an area of greater concentration to one of lesser concentration

digestion: a process in which fats, proteins, and carbohydrates are chemically changed into less complex molecules

diploid (DIHP loyd): having a chromosome number twice that found in gametes

disaccharides: carbohydrates that consist of a double molecule of sugar (An example is sucrose.)

dissect: to cut apart for scientific examination

DNA: see deoxyribonucleic acid

dominant trait: genetic trait which prevents the expression of the recessive trait

dorsal (DOR sul): toward the back

ecdysone (EK duh sahn): hormone that causes molting

ectoderm (EK tuh durm): outer layer of cells

egg: sex cell produced by females

elongation region: cells of the meristem which grow only in length adding to the length of a young stem or root

embryo: young organism that begins development after fertilization

endocrine (EN duh krun) **gland:** ductless gland, pours hormones directly into blood

endoderm (EN duh durm): inner layer of cells

energy: the ability to do work and cause changes

enzyme (EN zime): protein that speeds up chemical reactions

epicotyl (EP ih kaht ul): first true leaves of a plant

epidermis (ep uh DUR mus): outermost layer of cells of an organism

esophagus (ih SAHF uh gus): food tube from the mouth to the stomach

estrogen (ES truh jun): female sex hormone

evolution: process of change with time during successive generations among living things

excretion: getting rid of wastes

expiratory reserve: amount of air remaining in the lungs after exhaling normally but which can be expelled

eyespot: two light sensitive organs at the anterior end of planarians

family: subdivision of an order

fats: complex molecules made up of glycerol and fatty acids (Fats may be stored in the body and are a source of energy.)

fatty acids: molecules which combine with glycerol to form fats

fertilization: fusion of egg and sperm

field of view: area seen through a microscope

flagella (fluh JEL uh): long, whiplike projections of a cell used for locomotion

flower: structure for sexual reproduction in angiosperms

follicle: cell nest within an ovary; site of egg development

follicle stage: stage in the menstrual cycle during which an egg matures and the preparation of the uterus for a possible pregnancy begins

follicle-stimulating hormone (FSH): hormone which stimulates the ripening of eggs within the follicle of the ovary

fossil: any evidence or part of a once-living thing

frond: leaf of a fern plant

fruit: enlarged ovary of a plant that aids in seed dispersal

funiculus: stalk of a plant ovule

gametes (GAM eets): sex cells; sperm and eggs

gametophyte (guh MEET uh fite): the monoploid part of the life cycle of a plant or plantlike protist

gene: unit responsible for transmitting hereditary traits; segments of a DNA molecule

genetics: study of how certain traits are passed from parents to offspring

genotype (JEE nuh tipe): particular combination of alleles of an organism

genus (JEE nus): classification division between family and species; first word in the scientific name of an organism

germination: growth or sprouting of a plant from a seed
gibberellin (jihb uh REL un): plant hormone that affects plant growth

gill: respiratory organ in fish and other aquatic animals; spokelike structure in the cap of a mushroom where spores are produced

glycerol: molecule which is a component of fats

glycolysis: first step in cellular respiration in which glucose is broken down into two molecules of pyruvic acid

goiter: disease characterized by enlargement of the thyroid gland, often caused by lack of iodine in the diet

gram: basic SI unit of mass

grey matter: substance that makes up the interior of the spinal cord

guanine (GWAHN een): one of the bases in nucleic acids

guard cells: cells which surround and control the size of the stomata in leaves of complex plants

gymnosperms (JIM nuh spurmz): class of seed plants in which seeds develop unprotected on the scales of cones

heterotroph (HET uh roh trohf): organism which cannot make its own food

heterozygous (het uh roh zI gus): having two different alleles for a given trait at corresponding sites on homologous chromosomes

hilum: a scar on a seed marking where it was once attached to the ovule

homologs (HOH muh lawgs): the two chromosomes of a pair with the same kinds of genetic messages

homozygous (hoh muh zI gus): having two identical alleles for a given trait at corresponding sites on homologous chromosomes

hormone: complex molecule that directs chemical control within the body of an organism

host: organism from which another organism benefits

hybrid: result of a cross between parents of different genotypes

hypocotyl (HI puh kaut ul): embryonic seed structure that develops into part of the root and stem

inherited: passed on by genes to offspring

inhibitory effect: effect produced by the interaction of hormones that slows or interferes with hormone production

innate (inh AYt) **behavior:** behavior that is genetically passed from parent to offspring; behavior that does not change

International System of Measurement (SI): special language of measurements and their symbols used by scientists and by other people in most countries throughout the world

interphase (IHNT ur fayz): period between mitoses during which chromosomes are replicated

invertebrates: animals without backbones

iodine test: test used to determine if a substance is a polysaccharide

joint: where body segments of arthropods meet; where bones of vertebrates meet

juvenile hormone: hormone involved in the final transition of an insect pupa to the adult form

karyotype (KER ee uh tipe): pattern of chromosomes grouped into pairs and organized by size

kingdom: broadest division in the classification of living organisms; the five kingdoms are monerans, protists, fungi, plants, and animals

larva: stage of development in some animals during which much growth occurs, sometimes through a series of molts

learned behavior: behavior that can be changed

litre: basic SI unit of volume

litmus: a chemical indicator which is blue in the presence of a base, pink in the presence of an acid

lutening hormone (LH): hormone which causes the follicle to change to the corpus luteum

macroscopic: visible without the aid of a microscope

marine: living in salt or ocean water

marriage line: line in a pedigree which indicates that two individuals are married

meiosis (mi OH sus): cell division resulting in sex cells

menstrual (MEN strul) cycle: monthly series of hormonal changes leading to egg maturation and uterus preparation for a possible pregnancy

menstruation (men STRAY shun): stage of the menstrual cycle usually lasting from three to five days during which blood, some uterine tissue, and the unfertilized egg are expelled from the vagina

meristem (MER uh stem): special region of plant tissue where cell division occurs

mesoderm (MEZ uh durm): layer of cells between the ectoderm and the endoderm

metamorphosis (met uh MOR fuh sus): series of changes in form during development of an immature form to an adult

metaphase (MET uh fayz): phase of mitosis in which chromosomes move to the "equator" of the cell and become attached to spindle fibers by their centromeres

metre: SI unit of linear measurement

methylene blue: chemical indicator which detects a decrease in the amount of oxygen present

micropyle: opening in the ovule of a flowering plant through which sperm nuclei enter

microscope: a scientific instrument used to magnify small objects so they can be easily seen

microscopic (mi kruh SKAHP ihk): too small to be seen with the naked eye

mitosis (mi TOH sus): process of cell division that results in two cells which are identical to the parent cell

model: representation of something; description used to help show what something is

molecule: combination of two or more atoms joined by a covalent bond

molting: process of shedding the outer layer of skin, feathers, or exoskeleton

moneran: very small organism, usually one cell in size, that lack nuclei; bacteria and blue-green algae

monocot: plant whose seeds contain one cotyledon

monoploid (MAHN uh ploid): having a chromosome number equal to that found in the gametes

monosaccharide (mahn uh SAK uh ride): carbohydrate that consists of a single molecule sugar (Examples are glucose, fructose, and galactose.)

motile: capable of movement

motor nerve: nerve that carries messages from the spinal cord to a muscle

mouth: opening in body through which food enters and in some animals through which wastes leave

mRNA: RNA which carries the genetic code of DNA; necessary for protein synthesis

muscle: specialized tissue which contracts

mutation (myew TAY shun): a difference from what is considered to be the normal sequence of bases in a molecule of DNA

nephridia (nih FRIHD ee uh): excretory organs of an earthworm

nerve: bundle of neuron fibers

neuron (NOO rahn): specialized cell of the nervous system which conducts impulses; nerve cell

neutral solution: solution which is neither acidic nor basic

nonvascular plants: plants which do not have conductive tissues or true roots, stems, or leaves

nuclear membrane: thin covering that surrounds the nucleus of a cell

nucleoli (NEW KLEE uh li): small body within the nucleus of a cell that breaks apart during cell division

nucleotide (NEW klee uh tide): subunit of nucleic acids, composed of a sugar, a phosphate group, and a nitrogen base

nucleus: control center of the cell

nutrient agar: special growth medium used to grow bacteria and other cultures

nutrients (NEW tree untz): chemicals in food needed by the body for proper functioning

offspring: result of sexual or asexual reproduction

optical illusion: mistaken idea that comes from something seen

order: subdivision of a class

organism: a living thing

osmosis (ahs MOH sus): diffusion of water across a semipermeable membrane

ovary (OHV ree): swollen lower region of the pistil in plants; female gonads in animals; where eggs are produced

ovulation (ahv yuh LAY shun): short stage in the menstrual cycle in which the follicle bursts and the mature egg is released

ovule (OHV yewl): female sporangium within the ovary of a flowering plant

palate: roof of mouth

parasite: organism that lives in or on a host and gets nourishment from the host

pedigree: diagram that shows the occurrence of a particular genetic trait over several generations of a family

petal: flower part, often brightly colored, which protects the inner reproductive structures and attracts insects

petiole (PET ee ohl): slender stalk of a leaf, attaches leaf to the stem

permeable: having pores or membranes which allow substances to pass through

pharynx (FER ingks): throat; tube through which food passes after it leaves the mouth in planarians and earthworms

phenotype (FEE nuh tipe): physical or visible trait which a genotype determines

phloem (FLOH em): tubelike cells that carry food in plants

phosphate groups: molecules which, along with ribose and adenine, make up ATP

pH scale: scale of numbers representing the concentration of hydrogen ions and hydroxide ions in a solution

photosynthesis: the process in which plants use sunlight, carbon dioxide, and water to make food

phylum: largest division of a kingdom

pileus: cap (top) of a mushroom

pistil (PIHS tul): female part of a flower

plasma: fluid portion of blood containing salts, digested foods, and water

plasmolysis (plas MAHL uh sus): loss of water from cells due to osmosis

platelet (PLAYT lut): blood cell fragment lacking a nucleus; involved in blood clotting

point of insertion: site where a muscle attaches to a bone that moves

point of origin: site where a muscle attaches to a bone that does not move

pollen grain: structure which contains the male sex cells of some plants

pollination: process by which pollen reaches the female gametes

pollution: introduction of materials into the environment which decrease the purity or cleanliness of the environment

polysaccharide: carbohydrate that consists of many single molecule sugars chemically joined (Examples are starch, glycogen, and cellulose.)

population: group of organisms that naturally interbreed

posterior (pah STIHR ee ur): hind end of an organism

PPM: "parts per million"

producer: living thing which can make its own food

progesterone (proh JES tuh rohn): hormone secreted by the corpus luteum; maintains the uterus in its prepared condition for pregnancy

prophase (PROH fayz): first phase in mitosis during which the nucleolus and the nuclear membrane disappear and chromosomes become clearly visible as separate bodies

protein: complex molecule made up of chains of amino acids; needed for growth and repair

protists: very small organisms, usually one cell in size, that have nuclei

protractor: instrument used for measuring angles

pseudopodia (sewd uh POHD ee uh): structures of locomotion and food getting; false feet in amoeba

puberty (PYEW burt ee): onset of development of secondary sexual characteristics

Punnett square: chart used to determine the possible genotypes of the offspring of a cross

pupa (PYEW puh): stage of an insect life cycle in which the tissues of the organism are completely reorganized during complete metamorphosis

pyloric cecum: digestive organ of starfish

radicle (RAD ih kul): embryonic seed structure that becomes the primary root

ray: "arm" of a starfish

recessive (rih SES ihv) **trait**: form of a trait which is dominated by another form of the same trait

red cell: blood cell that transports oxygen and some carbon dioxide

reflex: simple response which involves no conscious control

reflex arc: path of the impulse in a reflex

regeneration (rih jen uh RAY shun): regrowing of missing parts; a form of asexual reproduction

residual volume: amount of air in lungs that cannot be expelled

retina: sensory membrane of the eye connected to the brain by the optic nerve

rhizoid (RI soyd): rootlike part of a nonvascular plant

ribonucleic (ri boh NOO KLAY ihk) **acid**: molecule found in the nucleus of a cell

ribose: molecule which, along with adenine and phosphate groups, makes up ATP

RNA: see ribonucleic acid

salivary (SAL uh ver ee) **amylase**: enzyme present in saliva which changes starch to glucose

saprophyte (SAP ruh fite): organism that obtains its food from dead organisms or from waste products of living things

scientific method: steps used by a scientist to solve a problem including observation, experimentation, interpretation, and hypothesis formation

scientific name: two word name for an organism which is known worldwide; genus and species

sclera: "white" of the eye

second: basic unit of time in SI

seed: reproductive structure which contains the embryo plant and endosperm

seed coat: hardened outer covering of a seed

segmented: divided into units

self-regulating: self-controlled

semipermeable (sem ih PER mee uh bul): having pores or membranes which only allow certain substances to pass through

sensory nerve: nerve that carries messages from receptors to the spinal cord

sepal: green, leaflike structure found at the base of a flower

sessile: incapable of movement or locomotion

sex chromosomes: chromosomes (X and Y) which determine sex

sex-linked trait: trait whose gene is located on the X chromosome

sexual reproduction: union of two sets of DNA to form a new individual

skeletal muscle: muscle attached to bones; voluntary muscles

smooth muscle: muscle that moves many of the internal parts of the body; involuntary muscle

solubility test: test used to identify fats

soluble: capable of being dissolved

sorus: reproductive structure of ferns containing spores

species: subdivision of a genus; group of organisms that normally interbreed and produce fertile offspring; second word in a scientific name

spindle fibers: oval shaped structures between opposite poles of a cell; structure to which chromosomes become attached in mitosis and meiosis

spirometer: type of equipment used for measuring lung capacity

sporangiophores (spuh RAN gee uh forz): clear stalklike parts of fungi that support the sporangia

sporangium: structure that produces spores in some organisms

spore: one celled structure produced by some organisms for reproducing asexually

sporophyte (SPOR uh fite): plant in which the cells are diploid and spores are produced

stalk: part of leaf that holds the blade on the stem; lower part of an anther

stamen (STAY mun): male part of a flower

stem: main stalk of vascular plants, supports the plant and transports materials

sterile technique: laboratory procedure that prevents contamination

stigma: sticky part of a female flower

stimulatory effect: effect produced by the interaction of hormones resulting in increased hormone production

stinging capsules: special cells found in tentacles of *Hydra* used for protection and food getting

stipe: stalklike part of a mushroom

stolon (STOH lun): threadlike structures of molds which absorb nutrients from the food supply

stomata (STOH mut uh): tiny pore in a leaf surrounded by guard cells

structural formula: formula which shows the arrangement of the atoms of a molecule

style: stalklike portion of the pistil

survivorship curve: graph of the number of people surviving in each age group in a given period of time

systole: contraction of the heart chambers

taxonomy: the area of life science which deals with classification

telophase (TEL uh fayz): last phase of mitosis in which the events are those opposite prophase

telson: fanlike tail found on some arthropods

temporary wet mount: mount made of a specimen for microscopic viewing using a slide, water, and a coverslip

testis (TES tus): male gonad

tetrad (TEH trad): group of four chromosomes present during one phase of meiosis

thermal pollution: pollution caused by excess heat

thymine (THI meen): one of the bases in nucleic acids

thyroid stimulating hormone (TSH): hormone produced by the pituitary gland which works to maintain the proper level of thyroxine in the body

thyrotropin releasing factor (TRF): hormone produced by the hypothalamus that works to maintain the proper level of thyroxine in the body

thyroxine (thi RAHK sun): hormone produced by the thyroid gland which controls metabolic rate of body cells

tidal volume: amount of air taken in or expelled during normal breathing

tissue: similar group of cells organized to perform certain functions

trait: a feature or characteristic of an organism

transcription (trans KRIHP shun): transferring the genetic code from DNA to RNA in protein synthesis

translation: operation and interaction of mRNA, tRNA, and amino acids to form a protein

translucent: semitransparent; allowing light to shine through

tRNA: RNA which brings amino acids to mRNA in protein synthesis

tube feet: hollow structures on the underside of a starfish; used in locomotion and food getting

uracil (YOOR uh sihl): a base in RNA but not in DNA

urea (yoo REE uh): nitrogenous waste which is a component of urine

urine: combination of urea, excess salts, and water

uterus (YEWU uh rus): thick-walled, muscular organ in female mammals where the embryo develops

uvula: small fleshy flap that hangs from the roof of the mouth

vacuole (VAK yuh wohl): cellular organelle used for storage

variations: differences in traits

vascular plants: plants that do have conductive tissue and true roots, stems, and leaves

vascular tissue: tissue which transports food, water, and minerals throughout plants

vein: conducting tissue of plants; blood vessel that carries blood to the heart

ventral (VEN trul): belly side of an organism

ventricle (VEN trih kul): chamber which pumps blood away from the heart

vertebra (VUR tuh bray): bone of the spine

vertebrate (VURT uh brayt): an animal in which the backbone (spine) has replaced the notochord

vital capacity: largest possible amount of air which can be exhaled from the lungs after drawing a deep breath

vitreous humor: fluid in the eye

water vascular system: system in starfish used for locomotion and food getting

white cells: blood cells that protect the body against infection

white matter: cells that make up the exterior of the spinal cord

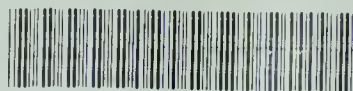
woody stem: stem containing woody tissue derived from xylem

xylem: vascular tissue that carries water and minerals in plants

zone of inhibition: area where bacterial growth is stopped by antibiotics

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LABORATORY BIOLOGY INVESTIGATING
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DATE DUE SLIP

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FEB 06 1992 RETURN	
DUE MAR 25 '92	
DUE EDUC APR 08 '92	
APR 08 1992 RETURN	
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SAFETY IN THE LABORATORY

The biology laboratory is a safe place to experiment if you are careful. You must assume responsibility for the safety of yourself and your neighbors. Here are some safety rules to help guide you in protecting yourself and others from injury in the lab.

1. The biology laboratory is to be used for serious work.
2. Do not perform experiments that are unauthorized. Always obtain your instructor's permission.
3. Study your laboratory assignment before you come to the lab. If you are in doubt about any procedure, ask your instructor for help.
4. Use the safety equipment provided for you. Know the location of the fire extinguisher, safety shower, fire blanket, and first aid kit.
5. Report any accident, injury, or incorrect procedure to your instructor at once.
6. Smother fires with a towel. If clothing should catch fire, smother it with a blanket or coat or quench it under a safety shower. NEVER RUN.
7. Handle dangerous materials only under the direction of your instructor. If you spill acid or another corrosive substance, wash it off immediately with water. Keep combustible materials away from open flames.
8. Never eat or drink anything in the lab. Never taste any chemical substance or draw poisonous materials into a glass tube with your mouth.
9. Place broken glass and solid substances in designated containers. Keep insoluble waste material out of the sink.
10. When your investigation is completed, be sure to turn off the water and gas and disconnect electrical connections. Clean your work area. Return all materials and apparatus to their proper places.

FIRST AID IN THE LABORATORY

1. Report all accidents or injuries, no matter how small, to your instructor.
2. Know where and how to report an accident or injury. Know the location of the phone and fire alarm, and where to locate the nurse.
3. In the case of injury, do the following:

INJURY	SAFE RESPONSE
burns, minor	Flush with water. Call your teacher immediately.
burns, severe	Call your teacher and get medical attention at once.
cuts and bruises	Follow the instructions in the first aid kit. Report to the school nurse.
fainting or collapse	Provide the person with fresh air. Have the person recline so that their head is lower than their body. Call your teacher. A nurse or a doctor may be needed to provide artificial respiration.
foreign matter in eye	Flush with plenty of water. Use eyewash bottle or fountain.
poisoning	Note the suspected poisoning agent and call your teacher.
severe bleeding	Apply pressure or a compress directly to the wound and get medical attention at once.
spills on skin acid spills base spills	Flush with water or use safety shower. Apply baking soda and call your teacher. Apply boric acid and call your teacher.

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